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RHIZOMA PERENNIAL PEANUT (*Arachis glabrata*) BASED ANIMAL PRODUCTION SYSTEMS FOR THE CARIBBEAN BASIN

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ABSTRACT

Rhizoma perennial peanut (RPP) is a perennial relative of the commercial peanut (*A. hypogea*) that is planted and perennates by means of rhizomes. Two cultivars, 'Florigraze' and 'Arbrook', have been released by the University of Florida for use as a forage for well-drained soils of the tropics and subtropics. In clipping trials, dry matter (DM) production has ranged between 6 to 12 Mg ha^{-1}. Forage quality is similar to alfalfa, with the whole plant crude protein (CP) between 12 to 18% and digestibility between 60 to 75%. Animal performance on RPP pastures (.9 to 1.0 kg d^{-1}) has been superior to that from most N-fertilized tropical grasses. Rhizoma perennial peanut persists well under a wide range of management systems for both hay production and grazing (rotational and continuous). Feeding trials and grazing studies indicated that RPP is suitable for dairy rations, backgrounding systems, creep grazing calves, and as limit-fed protein supplement.

INTRODUCTION

Numerous introductions of rhizoma perennial peanut (RPP), *Arachis glabrata* Benth., germplasm have been evaluated for forage potential at the University of Florida since the first plantings of Dr. W. Archer in 1936 (Prine, 1964). Little commercial utilization of available material occurred prior to 1980. Three recent developments have been sited by French (1988) as being responsible for the increased acceptance and utilization of RPP during the 1980's: 1) the release of the improved cultivar 'Florigraze' (Prine et al., 1981); 2) determination of a more optimum planting time; and 3) adaptation of mechanized digging and planting machinery. Over 1000 ha of RPP have been established in the United States, and are being used mainly for hay and planting material production. This paper will summarize the current understanding of various aspects of RPP production and management, and how RPP could impact livestock production in the Caribbean.

ECOLOGICAL ADAPTATION

A rhizome forming relative of the common peanut (*Arachis hypogea* L.) (Gregory et al., 1973), RPP is native to South America with various ecotypes occurring between 8° and 35° south latitude (Hermann, 1954). Although bright-yellow to orange flowers are frequently present, most of the introductions evaluated produce essentially no seed. The main reproductive structure of RPP is rhizomes, which occur in a thick mat just below the soil surface.

Adapted to well-drained, acid-infertile soils, RPP has been listed as a potential legume for low pH (<5.0) soils in the Caribbean (Paterson, 1986). None of the RPP germplasm evaluated so far is tolerant to extended periods of saturated soil conditions (see Kretschmer and Wilson [1988] for information concerning a flooding tolerant *Arachis* sp. currently being evaluated as a forage). Peanut roots have been observed to extend 3.5 m into the soil profile (French, 1988) and contribute to the drought resistance of established stands. Dry matter (DM) accumulations of 6 to 10 Mg ha^{-1} have been reported for Florigraze in south Texas where annual rainfall averages approximately 700 mm (Ocumpaugh, 1990). The cultivar 'Arbrook' has superior DM productivity under drought conditions than Florigraze; in 4 yr averaging over 2 Mg ha^{-1} more DM than Florigraze at an excessively well-drained location in Florida (Prine et al., 1986). Under severe drought conditions, premature leaf senescence occurs (Ocumpaugh, 1990; Williams et al., 1990), greatly restricting forage availability, but recovery is rapid after adequate rainfall (Prine et al., 1981; Ocumpaugh, 1990). This suggest that RPP would be most productive in the humid tropics and acid savannas which compose 23% of the land area of the Caribbean Basin (Couto, 1987).

Although not frost tolerant, Florigraze has been reported to survive winter temperatures as low as -14°C (Prine et al., 1981). Sprouting has been observed in Florida during extended frost-free winter periods (Prine et al., 1981); temperature requirements for Florigraze growth appear to be similar to that of 'Pensacola' (*Paspalum notatum*) bahiagrass (M.J. Williams, personal observation). Arbrook is less cold tolerant than Florigraze (Prine et al., 1986). Dry matter productivity is more sensitive to cool temperatures than plant survival (Prine et al., 1981), and limits economic usefulness of available cultivars to subtropical areas of the U.S. Minimum temperatures should not be a limiting factor for RPP production in most of the Caribbean area (Paterson, 1987).

DRY MATTER PRODUCTION AND FORAGE QUALITY

Under favorable growing conditions dry matter production of RPP has been calculated to exceed 40 Kg ha^{-1} d^{-1} (French, 1988). Total DM yields between 6 to 12 Mg ha^{-1} have been reported from numerous RPP clipping studies (Beltranena et al., 1981; Prine et al., 1981; Prine et al., 1986; Ocumpaugh, 1990). Forage quality (crude protein [CP] and digestibility) of RPP is similar to alfalfa (Table 1) (Prine et al., 1986). Component analyses have shown that leaf and stem digestibility exceeds 600 and 500 g kg^{-1}, regardless of maturity (Ocumpaugh, 1990; Salvidar et al., 1990). This indicates that RPP forage would support positive animal performance regardless of maturity. Management systems to stockpile RPP growth from the late summer (or late wet-season in the tropics) could be a practical option for livestock producers.

Table 1. Percentage of protein and *in vitro* organic matter digestibility (IVOMD) in two rhizoma perennial peanut cultivars at three harvest dates in Gainesville, FL., three year average.

	Harvests							
Cultivar	June	Aug.	Oct.	Season Avg.	June	Aug.	Oct.	Season Avg.
	-- crude protein, % --				------- IVOMB, % ------			
Arbrook	13.8	13.7	14.3	13.9	62.8	65.6	67.4	65.3
Florigraze	14.0	16.1	14.9	15.0	63.2	66.3	65.0	64.8

(adapted from Prine et al., 1986)

ESTABLISHMENT

Lacking seed and the stems not readily rooting (Harris et al., 1982), RPP must be vegetatively established by digging and transplanting rhizomes. A common practice of many Florida RPP growers, is to establish a nursery area (.5 to 2 ha) to grow their own planting material. Depending upon planting rate, 1 ha of well maintained nursery material, when dug every second or third year, will provide enough rhizomes to plant 10 to 20 ha at each digging. Modified potato diggers, peanut diggers or grass sprig diggers have been used (Prine et al., 1986). Rhizomes can be broadcast and disked in, hand planted in rows (<60 cm apart), planted in rows with vegetable or tobacco transplanters, or with a grass sprig planter (Prine et al., 1986). Stand establishment was equally good with either the broadcast/disk method or sprig planter (French, 1988). What ever the digging method, rhizomes should not be allowed to dry out before planting (Prine et al., 1986). Rhizomes should be well covered (Prine et al., 1986), but shallowly planted. Sprout numbers were reduced by 50 to 80% when rhizomes were planted deeper than 3.75 cm (French, 1988). Cultipacking or rolling after planting is recommended (Prine et al., 1986). A minimum planting rate of 3.5 m^3 ha^{-1} is recommended, when rhizomes must be purchased (Prine et al., 1981; Prine et al., 1986), but when home-grown material is available double that rate is used to insure quicker cover.

The relatively slow spread rate of RPP after planting, often taking >3 yr for full cover, is recognized as the greatest restriction to increased use of this forage species (French, 1988; Salvidar et al., 1990; Williams, 1990). Complete cover has been achieved by the end of the first growing season, but this has proved to be the exception for most dry land plantings. Factors such as planting rate and date, rhizome quality, plantbed preparation and depth of planting, weed competition, and moisture availability, all interact to affect RPP establishment and rate of cover.

In date of planting and plantbed preparation studies conducted under favorable moisture conditions, sprout numbers m^{-1} and survival (Table 2) was highest for winter planted rhizomes, planted in well-prepared (plowed and disked) plots (Williams, 1990). The effect of plantbed preparation on sprout numbers was consistent with cover estimates reported by Prine et al. (1984) for similarly prepared plantbeds. In less well-prepared treatments, the planter was unable to consistently place and cover the rhizomes, many of which dried out on the plantbed surface. Plantbed preparation affected sprout emergence more than survival in this study. Rate of spread after winter plantings, which allow newly established plants to grow the entire summer is generally superior to summer planted material (Prine et al., 1981; M.J. Williams, unpublished data). For these reasons, in the U.S. rhizomes are dug in the winter (December, January, February) after a frost has killed the top growth (Prine et al., 1981). Optimum planting time(s) under the tropical conditions need to be determined.

Weed control is essential during the establishment phase to enhance sprout survival and maximize rate of spread (Adjei and Prine, 1976; Prine et al., 1981; Prine et al., 1986). Canudas et al. (1989) reported a doubling of RPP DM at the end of the first growing season when grasses and broadleaf weeds were controlled compared to the no herbicide control. Tolerant of many herbicides labelled for edible peanut (A. hypogea), currently only three post-emergence herbicides (bentazon, acifluorfen, and sethoxydim) are labelled in the U.S. for use during establishment or for nursery maintenance (no grazing or haying permitted for 12 mo post application). Selective weed control with wiper applicators, by mowing, or even limited grazing has been useful for controlling weeds during establishment. When mowing or grazing is used to control weeds, it is essential that as little RPP material be removed as possible until the plants are well established.

Table 2. Effect of planting date and plantbed preparation on rhizoma perennial peanut total sprout emergence and percent survival.

	Planting Date			
	Winter	Summer	Winter	Summer
Plantbed Preparation	Emergence		Survival	
	--- sprouts m2 ---		-------- % --------	
Plowed[a]	60.7	31.7	60.5	51.0
Disked[b]	13.7	9.7	53.5	44.3
Sod[c]	1.9	8.5	6.7	53.2

[a] Plowed = bottom plowed and disked twice.
[b] Disked = disk twice.
[c] Sod = planted directly into sod.

(from Williams, 1990)

Nitrogen applications have not proved beneficial to RPP establishment (Adjei and Prine, 1976). Fertility studies have shown that under Florida conditions RPP DM production is relatively unaffected by P and K applications (Table 3) (Prine et al., 1984; Prine et al., 1986), but fertilization to soil test requirements for general legume production is recommended. Because the effect of pH and fertilizer application on RPP production has been investigated in only a limited number of soil types, further fertility studies under Caribbean conditions need to be conducted.

Table 3. Dry matter yields of two rhizoma perennial peanut cultivars at three fertilizer levels at the SCS Plant Materials Center, Brooksville, FL, three year average.

Cultivar	Fertilizer ($N-P_2O_5-K_2O$)	Dry Matter
	--- kg ha-1 ---	--- Mg ha-1 ---
Arbrook	0-0-0	12.8
	0-56-160	11.6
	0-112-260	12.8
Florigraze	0-0-0	10.3
	0-56-160	10.5
	0-100-260	11.2

(adapted from Prine et al., 1986)

Inoculation of RPP with Bradyrhizobium spp. has not proved beneficial to either top or rhizome growth (Adjei and Prine, 1976). This is probably because tremendous amounts of inoculum is transferred in the soil adhering to the rhizomes when dug. Rhizoma perennial peanuts readily nodulate with 'peanut' or 'cowpea' type inoculant.

MANAGEMENT OF ESTABLISHED STANDS

Maintaining optimum fertility and not removing any top growth as hay or by grazing is the recommended management of planting material nurseries (Prine et al, 1981). The minimum digging interval is every 2 yr, but in less favorable growing conditions, every 3 to 4 yr may be necessary.

Established RPP stands have proved to be remarkably persistent and tolerant of various management systems for either hay or silage production and grazing, both rotational and continuous. In clipping studies to determine optimum hay production management, Beltranena et al. (1981) found that as harvest interval increased (2 to 12 wk) leaf content of harvested material decreased from 93 to 72%, and CP and digestibility decreased from 21.9 to 14.7% and 74.3% to 64.8%, respectively. There was no significant difference in DM between 6, 8, 10, and 12 wk cutting intervals. They recommended 3 hay cuttings a year as a compromise between DM production with forage quality and ease of handling. Some concern has been express about frequency and timing of the final hay harvest in subtropical areas. Rhizoma perennial peanut stands have been winter killed when subjected to multiple harvest, while unharvested material survived (Prine et al., 1986). This is thought to be due, in part, to regrowth after the last harvest date exhausting the rhizome carbohydrate reserves prior to frost (Prine et al., 1986). Whether harvest frequency and timing is critical for stand survival in tropical areas, where frost is not a problem, but prolonged dry season might be, is in unknown.

Ortega-S. et al. (1990) conducted extensive investigations into the effect of grazing management on pasture productivity and stand persistence. They looked at combination of grazing frequency (simulated continuous vs 21, 42, and 63 d cycle) and grazing intensity (.5, 1.5, and 2.5 Mg residual DM ha^{-1}). Regardless of grazing cycle when residual DM was >1.5 Mg ha^{-1} RPP DM accumulation exceeded 7 Mg ha^{-1}. Crude protein content of the herbage was not affected by grazing management (20% CP, average of all treatments), while digestibility declined slightly as maturity increased. Little change in rhizome mass (indicative of plant reserves for regrowth and persistence) was observed above 1.5 Mg residual DM ha^{-1}. Peanut content of the pastures remained stable above 2.0 Mg residual DM ha^{-1} regardless of grazing cycle, but RPP content declined and common bermudagrass (Cynodon dactylon (L.) Pers.) increased with decreasing residual DM and increasing grazing frequency. They concluded that persistence was good under rotational grazing when residual DM was >1.0 Mg ha^{-1} and grazing interval was $\geq$35 d, and with continuous grazing when residual DM >1.5 Mg ha^{-1}.

Grasses are considered an undesirable component of established RPP swards because they result in generally lower forage quality. This is easily understood in hay production situations, but it is also true under grazing, as cattle have not been observed to selectively graze RPP in preference to most grasses in Florida (Prine et al., 1981; Williams et al., 1988). Lack of selective grazing has been sited as the reason for suboptimal animal performance in RPP grazing studies (Prine et al., 1981; Rusland et al., 1988). In a backgrounding study, average daily gains (ADG) of steers grazing swards containing 26% vs 45% RPP (season average) was .68 and .9 kg d^{-1} respectively (Williams et al., 1990). There are no herbicides labelled in the U.S. for grass control in established RPP stands that are grazed or hayed. Generally, grass contamination of the sward becomes less of a problem with proper management, as the RPP stand matures (M.J. Williams, personal observation). Limited research experience with deliberately established mixed swards indicates that RPP is generally an increaser in a mixed grass-RPP sward in the absence of N fertilization (Valentim et al., 1987). Maintaining the grass component in RPP sward may be desirable, when maximum forage quality is not necessary. The grass component may be useful for extending the grazing season, particularly in those areas where dry weather restricts RPP growth (Williams et al., 1990). The management for maintaining grass in RPP swards and the economics of grass-RPP combinations need to be investigated.

Broad leaf weeds tend to be increasers in RPP stands (M.J. Williams, personal observation). This is probably due to the rather open sod characteristic of a pure RPP. Broad leaf weeds present in Florida RPP stands reduce hay quality, but are generally avoided by grazing animals (Williams et al., 1988). No studies have been conducted to determine when broad leaf weed control would be economically warranted in established pastures.

Few insects and disease problems have been reported for either Florigraze or Arbrook in Florida. They appear to be resistant to Cercospora sp. and Cercosporidium sp. leaf spot and the common virus diseases of edible peanut (A. hypogea). Minor foliar diseases have been reported (Prine et al., 1986), but no long term damage has been observed.

PRODUCTION SYSTEMS

Pasture Based Beef Production

Meat production, generally a side line of the dairy industry in the Caribbean, is based primarily on natural grasslands, fallow crop lands and crop residue (McDowell, 1987). Under these conditions it takes 2.5 to 4.5 yr of age for animals to attain the desired 400 kg slaughter weight (McDowell, 1987). Economic constraints require that beef productions systems be low input (McDowell, 1987). Rhizoma perennial peanut could fit well in such systems, because of its long term persistence and low fertility requirements. Additionally, its relatively high nutritional quality compared to non-N fertilized tropical grasses, could result in a reduction in time to reach market weight. The possibility of using RPP in backgrounding systems and the quality of RPP pasture finished beef are being investigated at the Subtropical Agricultural Research Station.

A 2 year study investigating backgrounding alternatives for cattle producers in Florida was recently completed (Kunkle et al., 1988). Weanling steer calves previously wintered at two levels of nutrition, continuously grazed either N fertilized Pensacola bahiagrass or Florigraze RPP from April to September, prior to feedlot finishing. Steers grazing RPP pastures gained 42 kg more (.8 vs .5 kg $head^{-1}$ d-1) during the grazing season and had higher condition scores in September, than steers grazing bahiagrass. Plasma urea nitrogen (PUN) concentrations (indicative of the protein status of the animal relative to its energy intake [Hammond, 1983]) indicated that the protein intake of steers on RPP was never limiting during the grazing season (Williams et al., 1990). In contrast, PUN values of steers on bahiagrass indicated protein deficiency in the late summer and a decline in ADG was observed (Williams et al., 1990). Although between 20% to 50% of the additional gain from RPP was lost during the feedlot period, steers that had grazed RPP had heavier carcasses and larger rib-eye area than those on bahiagrass (Kunkle et al., 1988). Marbling and quality grade of the carcasses were not affected by pasture system (25% Choice and 62% Select).

Continued positive gains observed in the late summer indicated the possibility of producing slaughter weight calves directly from RPP pastures. In an ongoing background study utilizing spayed-heifers, 16 head grazed RPP from April until October and were slaughtered directly from pasture (W.E. Kunkle, unpublished data). Similar to a previous study with steers finished on RPP (Rusland, et al., 1988), none of the carcasses were discounted for fat color. Unlike the previous study where none of the carcasses graded Choice, 12% of the carcasses in this study graded Choice. These studies indicate that acceptable quality beef could be produced directly from RPP pastures.

Protein Supplementation for Cattle

Inadequate protein and energy, particularly around the time of parturition, is one of the biggest causes of infertility of cattle in the Caribbean (Roman-Ponce, 1987) and Florida. Purchased concentrates are regularly fed during the breeding season in Florida to insure economically efficient reproductive rates (Padgett et al., 1990). A trial was initiated in 1989 to determine the effect of limit feeding RPP hay as an alternative to purchased supplement for beef cattle during the breeding season for beef cattle (Padgett et al., 1990). These studies indicated that RPP (12.5% CP) limit-fed at approximately 2.2 kg $head^{-1}$ d^{-1} produced the same results as 1 kg $head^{-1}$ d^{-1} of purchased supplement (20% CP) in terms of cow weight, protein status, and pregnancy rate (Padgett et al., 1990). An economic analysis, based on 1989 costs, showed RPP hay used as a supplement feed could be half the cost of purchased supplement, depending on hay yield (Padgett et al., 1990). As supplement cost are higher in the Caribbean than the U.S., the economic benefit of producers raising their own supplement would be expected to be higher.

Creep Grazing

High calf mortality (10% on average for calves from 0-3 mo of age) and slow growth rate of surviving animals has a major negative effect on livestock production in the Caribbean (McDowell, 1987). Rhizoma perennial peanut has been shown to minimize cow weight losses and improve calf gains when calves were allowed to creep graze RPP pastures (Table 4) (French et al., 1987). This study suggest that the benefits from creep grazing RPP could result from both positive weight gains of the calves and by reducing cow weight loss during lactation, which might significantly shorten nutritionally induced post-partum anaestorus.

Table 4. Weight change of cows and calves grazing bahiagrass alone or with rhizoma perennial peanut (RPP) creep, 13 June to 5 Sept. 1985, Pine Acres Research Unit, Univ. Florida.

Grazing Treatment	Cow Weight	Calf Weight	Calf ADG
	-kg-	kg	kg
Bahiagrass[b]	-24.1	54.1	.62
Bahiagrass+RPP Creep[b]	-4.1	69.2	.78

[a] Cows and calves on bahiagrass alone.
[b] Cows on bahiagrass, calves on bahiagrass+RPP.

(adapted from French et al., 1987)

Dairy Production

Florida like the Caribbean is a milk deficit area, in part due to low nutritional quality of available forages. Rhizoma perennial peanut was investigated as a potential roughage source, either as hay or silage, in dairy rations for the state. In a study comparing alfalfa (*Medicago sativa*) haylage to RPP hay at two levels of concentrate feeding, within the CP range of 14 to 16% RPP milk yields were similar to alfalfa (French, 1988). In another study, RPP silage was substituted for corn (*Zea mays*) silage in the ratios of 0:50:50, 20:30:50, 35:15:50 or 50:0:50 RPP silage:corn silage:concentrate, respectively (Staples and Emanuele, 1988) Feed intake and apparent digestion coefficient was similar to the 100% corn silage diet for all levels of RPP silage except the high RPP diet, where intake and digestion was slightly lower. Highest milk yield was obtained on the diet containing 20% RPP silage (Table 5). The most profitable ration was the one that contained no corn silage. These data suggest that RPP could provide high quality roughage for dairy rations in those areas of the tropics where alfalfa or corn production is limited.

Table 5. Yield and composition of milk from cows fed diets containing rhizoma perennial peanut silage substituted for corn silage.

	Rhizoma perennial peanut			
	0%	20%	35%	50%
Milk yield, kg d^{-1}	34.4	30.9	29.8	28.8
Fat, %	3.4	3.45	3.42	3.51
Fat yield, kg d^{-1}	1.02	1.05	1.01	.99
4% fat-corrected milk, kg d^{-1}	27.5	28.2	27.1	26.4
Protein, %	3.14	3.03	2.99	2.90
Protein yield, kg d^{-1}	.95	.92	.88	.83

(from Staples and Emanuele, 1988.)

Non-ruminant Production

Rhizoma perennial peanut is thought to hold potential for use as a feed ingredient for horse, swine, poultry and rabbit diets. The palatability and quality of RPP is opening a market for commercial hay sales to the horse industry in Florida. Horses, when offered the choice of RPP or alfalfa round bails, consumed the RPP in preference to the alfalfa (E.C. French, personal communication). López et al. (1986) reported that a diet containing 80% RPP in the diet farrowed more pigs (11.5 vs 8.83) and had an equivalent number of pigs weaned (6.67 vs 6.67) as a 100% corn/soybean, (*Zea mays/Glycine max*). Feed conversion of rabbits fed RPP meal was superior to both alfalfa meal and Kudzu (*Pueraria lobata*) meal (2.6 vs 3.2 and 3.5, respectively) (French et al., 1987). Janky et al. (1986) concluded that RPP contains adequate levels of xanthophyll pigment for use as a commercial feed additive to poultry diets.

SUMMARY

Rhizoma perennial peanut has proved to be a rather unique forage legume, by combining the attributes of nutritional quality, palatability, productivity, and persistence, in a relatively harsh environment. Studies with various classes of livestock have all indicated the positive impact increased use of RPP could have on animal productivity in the subtropics and tropics. Currently available cultivars are considerably under utilized in the U.S., in terms of the potential acreage they could be grown on, and extension efforts to expand their use are continuing. Whether they will perform as well under the varied environments of the Caribbean Basin is unknown, but numerous ecotypes of RPP germplasm exist in South America that have never been evaluated for forage purposes (W.C. Gregory, personal communication). In addition to RPP types, other *Arachis* spp. have demonstrated good persistence and competitiveness with grasses (Grof, 1985; Kretschmer and Wilson, 1988). All of this argues for further research efforts with *Arachis* in any country where members of the genus might be adapted.

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