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SYSTEMS OF PASTURE SEED PRODUCTION IN LATIN AMERICA

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ABSTRACT

Five basic production systems by which seed of grass and legume cultivars arrive at the market are proposed and described. These are: 1. Traditional for grasses; 2. Legumes from plantation agriculture; 3. Legumes with physical support; 4. Grasses and legumes as pastures; 5. Grasses and legumes as crops. The particular species and countries where these systems presently exist are defined. The relative and future roles of these systems and the most pertinent areas for research are discussed thereby providing guidelines for future seed development strategies.

The availability and cost per kg of pure live seed to a beef producer frequently determines if the potential of a forage cultivar can be realized in terms of animal production. Even in Latin America where the predominant method of distribution and establishment of grasses has been by vegetative propagation, large scale pasture improvement within extensive cattle production systems is feasible only by means of seed. This is particularly the case with legumes and improved cultivars of grasses.

With the majority of tropical pasture species the production of seed is a relatively new endeavor, both commercially and from the viewpoint of scientific investigation. In Australia, Brazil, Colombia and Kenya, however, seed production has developed considerably in the last decade. The literature on pasture seed production is now expanding. The review of Humphreys (7), then Jones and Roe (8), provide the first comprehensive presentations of the classic components of seed production as applied to the present day range of species and cultivars. Numerous other publications relate either to the behavior and management of particular species, specific cultural practices or national summaries of seed production activities. Discussion of pasture seed production, however, is complicated by the number and diversity of species, either presently under commercial production or experimentation which may result in future release, and by the multiplicity of ways by which seed arrives at the market. Vicary (16) drew attention to the diversity of seed producing enterprises in northern Australia while Hopkinson (6) has described the progressive phases of build up of supply of a new cultivar.

This paper aims to provide a general description of how pasture seed is presently produced in lowland tropical Latin America but from the viewpoint of production systems. In addition, the role of research

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within each system and how these systems can respond to future needs is discussed.

SEED PRODUCTION SYSTEMS

A pasture seed production system is regarded as all the biological, technological and managerial components relating to a particular species and how these components interact in the production of seed as a marketable product.

In seeking to define such systems, emphasis has been placed upon: (a) the degree to which seed production is compatible with forage management for beef cattle or some other production enterprise. (b) The extent to which the biological requirements of the species for seed production are satisfied by: locating the crop in an appropriate geographic region and/or a specific site therein and/or applying cultural practices to various degrees of intensity and skill. (c) The grouping of species or cultivars receiving similar production components into the same system, aiming to minimize the number of systems but to avoid drastic generalitites.

Five basic seed production systems are proposed. These are:

System 1. Traditional for grasses
System 2. Legume from plantation agriculture
System 3. Legumes with physical support
System 4. Grasses and legumes as pastures
System 5. Grasses and legumes as crops.

System 1. Traditional for grasses

This system is confined to certain grasses, well naturalized in some livestock production areas, both in pastures and along roadsides. Their initital spread or establishment was either natural or for pasture, but not for the purpose of seed production. With the exception of limiting access of cattle after a certain date, the graziers apply no specific seed management practices. Flowering and seeding, however, are well synchronized with the termination of the wet season and in most years seed set is high and seed can be harvested as a cash crop.

Harvesting is conducted manually. It normally involves a contractual arrangement between the grazier and a traveling merchant who then subcontracts to local laborers to conduct the harvest. Some graziers, however, do organize and control their harvest. The main harvest method is to cut the flowering stems with a reaping hook or machete then construct orderly heaps with the stems arranged either horizontally or inclined upwards. The completed heap is covered with vegetative material. The heaps are constructed progressively in the field with the advance of the cutters through the field and only occasionally is the extra effort made to transport this material from the field to a shelter. After five to seven days the heaps are opened and the stems are threshed manually by being knocked against a stick or the ground. The detached seed mass is then bagged and transferred to shelter. Further cleaning is minimal and confined to removal of vegetative material. Final drying procedures are variable but normally involve exposure to the sun. An alternative harvest method is to simply enter an overmature crop and collect the fallen seed from the ground using rakes and brooms.

Commercial seed lots are extremely variable in all components of quality. The most obvious character of such seed is the high but variable contents of sand, soil, parts of leaves and stems and empty "seed". Conversely the seed technologist would describe the same seed lot as having low but variable purity (by the International definition) and a high inert matter content. Obviously the seed collected from the ground will have the highest sand and soil fraction. On the other hand particular seed lots can be almost free of sand, soil and vegetative material. The constant variable is the proportion of seed-like structures containing a caryopsis, i.e. the content of pure seed by the International definition. Germination, too, is highly variable relating to the content of pure seed, the proportion of inmature seed and post-harvest handling, especially time and conditions in the heaps, the rate of drying and storage conditions.

Seed yields are highly variable and estimates are complicated by the difficulty in measuring area of harvest and the weight and purity of the final product.

Seed sales are essentially local and without any standard definitions or estimates of quality. In particular regions seed is traded commercially and may move across adjacent national borders, i.e., from Colombia to Venezuela.

This system has developed and functions without any governmental assistance or research input. While the product is unrefined and variable, this system produces the largest volume of pasture seed and it is the most widespread grass seed production system throughout Latin America. Species, countries and yields are summarized in Table 1. By far, the greatest total production occurs in Brazil and Colombia.

Aspects of production and development of this system have been described by several authors (1, 5, 9, 12, 15). Examination of the basic nature of this system would indicate that to improve firstly quality and then quantity of production, an intensive research effort is not required but more the application and extension of available technology. Research efforts to understand more of the effects and control of the sweating phase, i.e. while the harvested material is kept moist in heaps (14), and to develop more appropriate seed processing equipment (11) should be continued.

Table 1.Distribution and seed yields of grasses in the traditional grass system (System 1).

Species	Country	Seed yield*
		kg/ha
Hyparrhenia rufa (Nees) Stapf.	Brazil, Colombia, Costa Rica, El Salvador, Guatemala, Mexico Panamá, Perú, Venezuela	100-200 (1 harvest)
Panicum maximum Jacq.	Brazil, Bolivia Costa Rica, Colombia, Ecuador, Mexico, Venezuela	50-100 (1-2 harvests)
Dichanthium aristatum (Poir.) C.E. Hubbard	Colombia, Venezuela	75-150 (1-2 harvests, often irrigated)
Melinis minutiflora Beauv.	Brazil, Colombia Costa Rica, Venezuela	75-150 (1 harvest)
Cenchrus cicliaris L.	Colombia, Mexico, Venezuela	50-100 (1 harvest, without heaping)

*Unrefined seed of variable but generally low purity.

The system could be improved in the following ways:

1) Refined on-farm, post-harvest management. Firstly, more understanding and control of the sweating phase. Secondly, the use of cheap plastic sheeting and inclined scalping screens during the threshing phase to reduce the proportion of inert matter. Thirdly, more emphasis upon slow, natural drying under shade.

2) Off-farm mechanical seed processing to improve the purity of marketed seed. This could be provided either by a national institution or private individuals organizing a processing facility within a major production area. Equipment required may include a pre-cleaner or a scalper, an adjustable hammer-mill or a debearder and air-screen cleaner and a gravity table.

3) Developing an increased understanding of seed quality. The first requirement would be a standard definition and measurement of seed purity for each species, then the development of a seed testing service facility. The latter would be best provided by a national institution. Also required would be an educational program to emphasize the roles of purity, germination, pure live seed content and their relationship to seeding rates.

4) Encouraging particular land owners to engage more seriously in seed production. This would involve a commitment to the selection of uniform, weed-free pasture seed production areas and more intensive management. In some mixed crop and cattle production regions, it should be possible to use slashing and combine harvesting with specific adjustments or adaptations of equipment used for food crop production.

Several large commercial seed companies are entering into contractual arrangements with graziers; therefore, this system is likely to be more productive in the future. It should be noted, however, that a high degree of refinement of this system would constitute a transition to System 4.

System 2. Legumes from plantation agriculture

This system is confined to legumes capable of providing stable ground cover under perennial tree plantations in the humid tropics. Plantations for rubber, palm oil and coconuts are developed obviously where ecological conditions favor these particular crops. The legume provides a living mulch for control of erosion and weeds and becomes progressively under partial shade. Seed production from the legume is not an initial objective, but is an occasional secondary cash crop.

Grazing is not a part of the management system in rubber and oil palm plantations. The legume is manually cut away from the base of the trees and may be defoliated occasionally either manually or mechanically. Pre-harvest management of the legume is essentially minimal or zero.

Within a minority of plantations and only in some years, seed set of the legume may be relatively prolific in parts of the plantations. Some managers divert labor to manual seed harvesting, generally the wives and children of permanent workers. Harvested pods are sun dried and threshed manually.

The marketed product is of high purity but with variable germination which is related to seed age and storage conditions. Seed supply from this system is obviously irregular. Seed moves into national markets, but also moves internationally because of the marketing contacts of the plantation industry. At present within Latin America only *Pueraria phaseoloides* (Roxb.) Benth var. *javanica* (Benth) Bak. is produced from within African oil palm or rubber plantations (Table 2). It is important to note, however, that other legumes, such as *Centrosema* spp., and *Desmodium ovalifolium* Vahl. could be produced within this system.

The seed yield potential of *P. phaseoloides* without physical support is not well defined in Latin America. At Carimagua in eastern

Table 2. **Distribution and seed yields of *P. phaseoloides* within the plantation agriculture system (System 2).**

Species	Country	Seed yield
		kg/ha
P. phaseoloides with African oil palm or rubber	Brazil, Colombia, Ecuador, Guatemala	10-50 (1 harvest)

Colombia (4ºN), Raúl Pérez (personal communication) has recorded hand-harvested yields between 5 and 80 kg/ha from pure stands. At CIAT's headquarters, (3ºN) yields of 500 and 340 kg/ha were recorded from hand and direct combine harvesting, respectively. The species, therefore, does have an attractive seed yield potential essentially unexploited at present in Latin America.

As large areas of *P. phaseoloides* presently exist and will expand consistent with the growing plantation industry, means to increase the volume of *P. phaseoloides* seed, or of other species, within this system should be examined. These include:

1) Improved laison between the plantation and pasture seed industries as regards definition of demand, production potential and methodology and sharecropping agreements.

2) Purposeful selection of specific geographic regions where the legume would consistently produce reasonable seed yields. Included here are considerations of: latitude, as *P. phaseoloides* has a short-day flowering response, lowland low latitude areas have a lower yield potential, but yields should be attractive above 8º latitude even at low altitudes; rainfall distribution relative to daylength, in particular the requirement for a marked change to a consistent dry season combined with shorter photoperiods; radiation levels, avoiding areas with consistently high cloud cover throughout the year.

3) Selection of specific areas within plantations which are located within optimal geographic regions. These areas would have: minimum shading either because of young trees, low tree density or old diseased tree populations; light soil types, promoting moisture stress in the dryer season; flat topography, preferably with complete land clearing to facilitate mechanized crop management.

4) More intensive management of these selected areas for seed production. Included here may be: fertilizer application for the legume, especially to fulfill requirements for P, S, K, Mg, Zn or Mo; insect control, if and when needed; determination of harvest method related to availability of labor or the potential for a direct combine harvest, possibly on a contractual basis; the benefit of a cheap partial support system to facilitate a hand harvest.

System 3. Legumes with physical support

This system is confined to legumes with a twining growth habit. Areas of legume are established and then a support system is erected and the stems encouraged to climb the supports. The support system is usually a bamboo and wire combination, or may be simpler and more variable using plant stakes or old stems without interconnection.

Seed production is the primary objective. No specific consideration is made for selection of an appropriate geographic location, in fact, a lack of climatic adaptation for seed production in the particular location may be partially compensated for by the support system.

The support system negates alternative use by grazing, facilitates the obligatory hand harvest but restricts the size of the production area. Management is semi-intensive and may include fertilization, insect control and irrigation to promote high yields and thereby compensate for the cost of the support system. Pods are harvested manually and repetitively, normally on a programmed sequence. Pods are simply sun dried and threshed manually or by simple mechanical means, i.e. a stationary thresher. Seed yields can be very high. Purity and germination are normally high. Seed is often used on the same property or sold locally. The species most frequently involved are listed in Table 3.

Lotero (10) reported high yields with *Calopogonium muconoides* Desv. producing 800 kg/ha, *P. phaseoloides* 838 kg/ha and *Glycine wightii* (R. Grah. ex Wight & Arn.) Verdc. 622 kg/ha in Medellín, Colombia. Farfán (4) reported yields at Porto Viejo, Ecuador, with *Centrosema pubescens* Benth. yielding 950 kg/ha, *Macroptilium atropurpureum* (D.C.) Urb. 267 kg/ha and *Macrotyloma axillare* (E. Mey.) Verdc. 280 kg/ha. At Santander de Quilichao, Cauca, Colombia, *Centrosema* spp., have yielded 650 kg/ha in the first year.

This system is efficient and practical only on a limited scale with valuable material where labor is cheap and readily available. These limitations, dictate a primary and transitory role for this system because if demand or costs for a particular species continue to rise, significant expansion of production can only occur by a transition to either System 4 or 5.

Research within this system should be directed towards assisting this transition by the identification of cultural practices and appropriate geographic regions such that mechanical harvesting is economic. Another line of research could investigate the use of low cost support systems, (including multiple crop combinations which could be mechanically harvested) and chemical growth regulators.

In the future this system will be used to initiate seed increase of promising germplasm within national institutions producing seed for experimental purposes and provide high and rapid multiplication rates to both seed producers or graziers initiating production of a new variety where initial seed supply is either restricted or expensive.

System 4. Grasses and legumes as pastures

This system can involve both grasses and legumes. The species or cultivars involved are relatively new. The geographic region involved is one where the species is well adapted for forage production, and in most years, also in terms of seed set. Initital establishment is for the purpose of developing improved pastures, either in pure or mixed stands. While the initital objective of

Table 3. **Distribution and seed yields of legumes grown in the physical support system (System 3).**

Species	Country	Seed yield
		kg/ha
C. pubescens	Colombia and	over 100
G. wightii	Ecuador	over 100
P. phaseoloides		over 100
C. mucunoides		over 100

the grazier is to produce forage for cattle production, he is attracted into becoming a seed producer either by high seed prices or the recognition that he can harvest his own seed for further property development. Seed production is therefore a secondary cash crop.

In the years when seed production is an objective, the grazier restricts grazing in particular areas and generally without any further input, this area is left to flower and set seed. These areas may have been fertilized to exploit the forage yield potential of new or improved cultivars. Harvesting is conducted by contract by either manual or mechanical means. The tendency however, is definitely towards combine harvesting. Seed is sun-dried on the property, but is generally transported to a processing facility where seed is cleaned and classified. The quality of final seed lots is variable but can be high. Seed yields are variable and generally moderate for the species. Total seed volume, however, is sufficient to significantly affect national supplies and prices as the areas involved increase.

This system is obviously intermediate between Systems 1 and 5. Some may even argue that it is not a discrete system. At present it is not common in Latin America, certainly not with legumes, but this reflects the scant number of relatively new pasture cultivars recently available (Table 4). This system is not promoted by research and development but tends to evolve naturally in response to strong economic demand for seed recognizable by progressive graziers within the same region. It is a relatively low cost method of seed production and if it develops on any scale, it negates the need for the development of System 5, for the particular cultivars involved within that particular country. The problem is however, that it is unlikely to develop rapidly enough for some cultivars and not at all for others, especially legumes in low latitude regions. The producers in this system are innovative entrepreneurs who move in and out of seed production depending upon the balance between seed prices and the need for forage. Some, however, are attracted into the enterprise and may become specialist producers*. The system, therefore, contributes both seed and seedsmen and is a bridging mechanism to the process of national seed improvement.

System 5. Grasses and legumes as crops

This system can include both grasses and legumes and the cultivars involved may be traditional or new. The principal objective is the production of seed, with limited emphasis upon production of forage. Land areas are selected and seed crops are established and managed towards this primary goal. A seed crop of a pasture

* See Rayman's chapter in this book. (Editor's note).

Table 4. **Distribution and seed yields of species in the pasture system (System 4).**

Species	Country	Seed yield
		kg/ha
Brachiaria decumbens Stapf.	Colombia, Venezuela and Brazil	5-50 (1-2 harvests)
P. maximum (cv. Colonião, Green Panic, etc.)	Brazil	50-100 (1-2 harvests)
M. atropurpureum	Brazil	20-50 (1-2 harvests)

species may form part of a food or fiber crop rotation and also provide secondary income from hay (especially with legumes) or limited grazing (especially with grasses).

This system develops within, or in time evolves towards, geographic regions best suited for the production of seed. In some cases specific climatic and edaphic ecologies are purposely sought out to locate seed crops. Such regions may be distinct and distant from the regions where the seed is used in pasture establishment.

A further dimension is the degree of management skill which is introduced by producers more inclined to apply specific cultural practices, mechanical ingenuity and concentration of effort.

Most producers have invested in specialized equipment, such as combines, artificial dryers, slashers, cultivating implements, seeders and seed processing machinery. Perhaps also land, irrigation equipment and sprayers are purchased. The need for large capital investment may lead to the involvement of corporate organizations, alone or linked to governmental agencies.

The full spectrum of conventional seed crop cultural practices are applied to the pasture seed crops as required; in particular, complete land preparation, high seeding rates, fertilizers, defoliation, integrated weed control (including cultivation and herbicides), insect control and appropriate efforts to maintain genetic purity. Irrigation may be applied to some species. The majority of crops are mechanically harvested, generally using conventional crop combines but the system may include manual harvesting. Seed processing is complete, and is conducted either on the same property or at centralized processing facilities. Seed is stored in appropriate sites.

Seed yields respond to the more intense management and more optimal environments, and are therefore higher and more consistent. Seed quality is generally higher reflecting both improved seed processing and storage conditions and quality control standards regulated by national agencies. Seed is marketed more systematically, both nationally and internationally.

This system is the most intensive and specialized. At present within Latin America it is not well developed or widespread as indicated by the species, countries and especially yields (Table 5). However, this system does offer greater opportunities for viable commercial production, higher yield and quality potentials, more consistent market availability and lower prices for many species. It is particularly appropriate for species or cultivars which either (a) have specific climatic, edaphic, pollination and/or isolation requirements to produce economically viable seed yields, (b) difficult maturity, harvesting or quality characteristics, or (c) constitute new cultivars, developed either by introduction or plant improvement programs. Ultimately only this system will resolve future demands for many legume species or will reduce prices to the consumer as the number of independent producers and areas under crop increase.

The developmental research by several authors (2, 3, 4, 13), the Instituto de Pesquisas IRI in Brazil, and the coordinating and publishing efforts of the Instituto Interamericano de Ciencias Agrícolas (IICA), have contributed significantly to the initiation of commercial production in various countries.

Research programs within national institutions are required to contribute towards the development and efficiency of this system. While these institutions tend to be naturally involved in inititating production, it must be stressed that ultimately production is most efficient in the hands of semi-autonomous organizations or independent operators. Research therefore, must be progressively modified to be responsive to their particular needs. Initially research

Table 5. **Distribution and seed yields of species in the crop system (System 5).**

Species	Country	Seed yield
		kg/ha
B. decumbens	Colombia, Bolivia Brazil	10-100
Brachiaria humidicola (Rendle) Schweickt.	Brazil	10-50
P. maximum	Bolivia, Brazil	20-50
Setaria anceps Stapf. ex Massey	Brazil	20-50
G. wightii	Bolivia, Brazil	100-300
Lablab purpureus (L.) Sweet	Bolivia	500-1200
M. atropurpureum	Brazil	30-100
Stylosanthes capitata Vog.	Brazil	50
Stylosanthes guianensis (Aubl.) Sw.	Brazil	30-75

should emphasize the definition of appropriate geographic regions for each species, regions with sufficient local diversity to accomodate various species, seed yields therein, the major determinants of seed yield and quality and the provision of basic seed stocks for potential producers. In time research should focus on the progressive refinement of economic production systems for a particular species, and/or general problems of the growers in a particular region.

Resources applied to seed production should be applied to adapted cultivars or promising germplasm. Both commercial seed producers and researchers need to be related closely to germplasm development and evaluation programs to ensure that this genetic prerequisite is fulfilled.

CONCLUSIONS

The availability and cost of seed of each pasture cultivar is the result of a production system, the major components of which are: the particular species and its reproductive mechanisms; the geographic region where it is grown for the production of seed; and the management practices applied. The five basic systems described here are by no means rigid but overlap and interrelate in the progressive development of seed supplies of any one cultivar. The descriptions are incomplete, especially as regards exact location of production regions within countries and precise production data which is simply not available in the literature.

Of fundamental importance for the development and economics of commercial seed production and any research effort to support this enterprise, is the definition and identification of appropriate geographic regions for seed production. Such regions provide favorable combinations of climatic, edaphic and management factors to consistently promote high yields and high quality of seed of a number of species and thus allow the growth of a viable seed industry. As national needs will always involve a number of species which could differ in seed production requirements, a given country will need at least one production region with a diverse array of local ecologies or several separate regions. These regions may be separate and distant from livestock areas inferring the need for organized seed movement.

The value of these partly conceptual seed production systems is in the analysis of how future seed needs can be fulfilled and the most appropriate role for the scant research resources available. Definition of the demand potential of proven adapted cultivars is the starting point for a seed production effort. Obviously each country can have different cultivars and volume requirements. If Systems 1 and 2 exist, their production potential should be closely examined. While System 4 suggests an ideal situation it cannot be assumed that it will develop rapidly enough to satisfy demand and it is unlikely to cater for many legumes especially in low latitude regions. System 5 will therefore be required to ensure sufficient rapid and consistent availability of seed at reasonable cost of many cultivars, especially existent and new legume cultivars. A research effort and specialized producers are both needed to develop this system, which will only be viable within particular geographic regions.

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