The Adaptation and Production of Species and Selections of Grasses and Clover in Colombia

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The cooperative agricultural research program of The Rockefeller Foundation and the Colombian Ministry of Agriculture was initiated in 1950. A division of forage and pasture crops, with responsibility for pasture management and grass and legume improvement, was added in 1955.

Prior to this time available information was largely observational and little was known concerning the distribution of grasses and legumes in Colombia, nor their adaptation, and potential productivity. Two of the initial projects conducted by the forage division were a survey of the pasture crops in common use in Colombia and the establishment of introduction nurseries in a number of climatic regions. This report is a review of the relative adaptation and production of the material studied in the collection gardens. The data obtained served as the basis for selecting the better adapted species, which were then placed in more extensive management trials such as rate and method of seeding, height and frequency of clipping, grass-legume mixtures, fertilization, and irrigation. These data were also used in the screening of material for the breeding program.

Materials and Methods

Nurseries were established in a number of locations at elevations from 150 to 11,000 feet above sea level. Seeds of forage and pasture crops were planted in rows 20 feet long and spaced 3 feet apart. Vegetative parts (stems, stolons, crowns) served to establish grasses such as bermuda, pangola, elephant, and guinea. A distance of 6 feet was left between rows of the pasture crops, which are spread by stolons or rhizomes. Each entry was duplicated or placed in triplicate. Lime, nitrogen, phosphorus, and potassium were added when soil tests indicated that these elements were low.

Notes were recorded periodically on habit of growth, height, spread, date of flowering, relative seed set, relative forage yield, and recovery after cutting. When a growth cycle was completed, the plants were cut and the procedure repeated. Data were collected from some nurseries for 2½ years and from others for 1½ years.

The material in the introduction gardens consisted of the most important pasture and forage crops used in Colombia and also a large group of grass and legume species supplied by the United States Department of Agriculture. The genera included were: *Agropyron, Agrostis, Andropogon, Anthoxanthum, Arrhenatherum, Avena, Axonopus, Bouteloua, Brachiaria, Bromus, Chloris, Coix, Cynodon, Dactylis, Digitaria, Eragrostis, Eriochloa, Festuca, Heteropogon, Holcus, Hyparrhenia, Ixophorus, Lolium, Melinis, Panicum, Paspalum, Pennisetum, Phalaris, Phleum, Poa, Saccharum, Sorghum, Stenotaphrum, Tripsacum, Cajanus, Calopogonium, Canavalia, Centrosema, Clitoria, Crotalaria, Desmodium, Dolichos, Glycine, Indigofera, Lathyrus, Lespedeza, Lotus, Lupinus, Medicago, Melilotus, Phaseolus, Pisum, Pueraria, Sesbania, Stizolobium, Vicia,* and *Vigna.*

The ratings (not adapted, poor, fair, good, and very good) shown in Tables 1 and 2 give the relative adaptation as measured by persistence, desirable agronomic type of growth, relative forage yield (scored on a rating of height, spread, leafiness and stemminess), seed production, and aftermath.

FIGURE 1. Annual white sweet clover *(left and background)* is well adapted over a range of altitude from 2,500 to 9,000 feet and makes excellent growth as compared to the biennial *(right and foreground)*, which seldom flowers.

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Results and Discussion

Colombia may be divided into four major climatic zones which are designated as hot, warm, cool, and cold. The boundaries are arbitrarily delimited by altitude as follows: Hot—0 to 2,500 feet, Warm—2,500 to 6,500 feet, Cool—6,500 to 10,000 feet, Cold—above 10,000 feet. Although many of the forage and pasture crops extend from one climatic division into another, optimum to maximum growth and production are generally obtained in the specific region of adaptation.

Hot Climate (0 to 2,500 feet.)

The area recognized as the hot climatic zone can be characterized as generally flat with some rolling plains and low sloping mountains which are not too steep. In the most important agricultural areas the soil pH ranges from 6.0 to 6.8[2], and generally phosphorus and potassium occur in sufficient amounts to sustain optimum growth of most crops. The mean annual temperature is 85° F. Rainfall varies with location; however, the usual pattern is 3 months of ample rain followed by 3 months of dry weather.

A rather large number of grasses grow in the hot climatic zone, of which many are quite productive. However, available legumes are limited. Common bermuda grass *(Cynodon dactylon)* and common bahia grass *(Paspalum notatum)* occur throughout the zone and are especially prevalent in overgrazed pastures. Brownseed *(Paspalum plicatulum)* flourishes from about 800 - 1,500 feet, especially in the Eastern Plains, and *P. conjugatum* thrives in the upper limits. Mixed with bahia can be found carpet grass *(Axonopus compressus)*. Para grass *(Panicum purpurascens)* abounds in the moist places, and guinea grass *(Panicum maximum)* and jaragua *(Hyparrhenia rufa)* are well adapted to the drier locations. In the lower limits pitted bluestem *(Andropogon pertusus)* is seen, and other weedy *Andropogons* are common. Among the introductions there are several guineas with fine leaves and stems which appear to be well adapted and of superior quality in contrast to the type commonly grown. Pangola grass *(Digitaria decumbens)* has recently become prominent as a pasture crop, and several other grasses appear promising: Dallisgrass *(Paspalum dilatatum)*, buffel grass *(Pennisetum ciliare)*, signalgrass *(Brachiaria decumbens)*, Rhodes grass *(Chloris gayana)*, and coastal, midland, and suwanee bermudas.

Tickclovers *(Desmodium* spp.) generally flourish in all pastures and constitute a fair percentage of the sward; however, seeds are not commercially available. Tropical kudzu *(Pueraria phaseoloides)* and jicama *(Calopogonium* spp.) prosper in most of the regions but are not in common use. Yields of alfalfa have been outstanding in the upper boundaries of the hot climatic zone and alfalfa may be cut every 5 to 6 weeks with ample water. A prolonged dry season results in diminished yields, and a striking deficiency of boron has occurred in some areas. Other legumes which may be utilized are velvetbean *(Stizolobium deeringianum)*, hyacinth dolichos *(Dolichos lablab)*, pigeon pea *(Cajanus* spp.), pigeonwings *(Clitoria* spp.), and rice bean *(Phaseolus calcaratus)*.

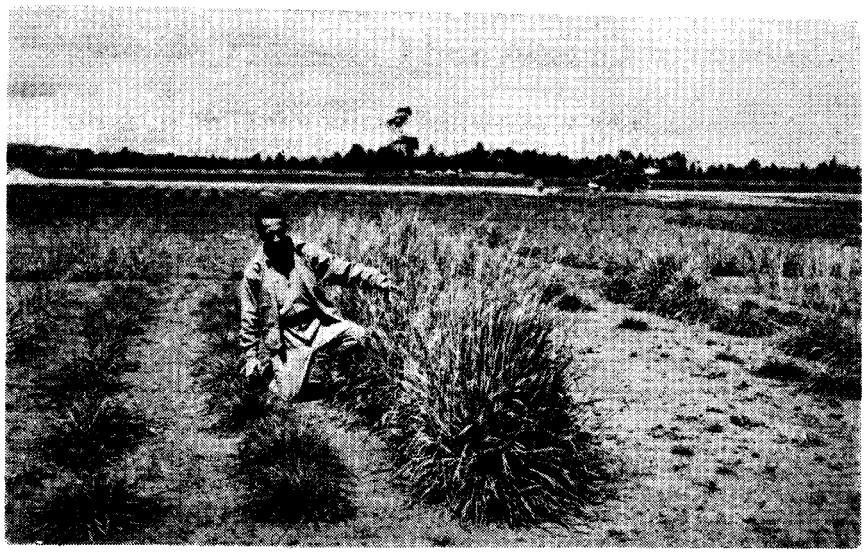

FIGURE 2. Harding grass *(left)* is not recommended, but the ryegrasses are well adapted to the cool climate and are highly productive. Perennial (English) ryegrass is shown in the center, with annual (domestic) ryegrass on the right.

Warm Climate (2,500 - 6,500 feet.)

Several rather large valleys, undulating hills, and rather steep mountains occur in this region. In the important agricultural areas the soil pH ranges from 5.5 to 6.5, and in some areas the soils are low in phosphorus and nitrogen. The daily temperatures vary from 65° to 95° F. and rainfall occurs in three-month cycles.

Bahia grass, sour paspalum *(P. conjugatum)*, bermuda grass, and carpet grass provide limited grazing throughout the region and are exceedingly beneficial in the conservation of soil on the steep mountain slopes. Para grass, guinea grass, and jaragua occur in the lower boundaries and molasses grass *(Melinus minutiflora)* is encountered in the upper limits and extends

[2] *Baird, G. B., Manuel Rodriguez J., Victor M. Vega J., and Alfonso Aristizabal G. 1957. The fertility status of soils in important agricultural areas of Colombia. Soil Sci. Soc. of Amer. Proc. 21: 405-408.*

Table 1. The relative adaptation of grass species and selections at eight locations in Colombia, South America.*

Species	Usme 11,000 ft.	Bogotá 8,500 ft.	Las Palmas 8,000 ft.	Manizales 6,500 ft.	Medellín 4,500 ft.	Palmira 3,000 ft.	Villa-vicencio 1,500 ft.	Montería 150 ft.
Andropogon pertusus	N	N	N	N	N	F	F	G
Anthoxanthum odoratum	G	F	F	P	N	N	N	N
Arrhenatherum elatius	F	G	G	P	P	N	N	N
Avena sativa	VG	VG	VG	P	P	N	N	N
Axonopus compressus	N	N	N	G	G	F	N	N
Axonopus Micay	N	N	N	G	F	N	N	N
Axonopus scoparius	N	N	N	VG	VG	N	N	N
Brachiaria decumbens	N	N	N	N	G	VG	G	G
Bromus catharticus	F	G	G	F	P	N	N	N
Chloris gayana	N	N	N	F	G	VG	G	F
Cynodon dactylon	N	N	N	N	G	G	G	G
C. dactylon (coastal)	N	N	N	N	VG	VG	VG	VG
C. dactylon (midland)	N	N	N	N	VG	VG	VG	VG
C. dactylon (Suwanee)	N	N	N	N	VG	VG	VG	VG
Dactylis glomerata	F	VG	VG	F	N	N	N	N
Digitaria decumbens	N	N	N	F	VG	VG	VG	VG
Eriochloa polystachya	N	N	N	N	F	G	G	F
Festuca arundinacea	F	G	G	F	N	N	N	N
Festuca elatior	F	G	G	F	N	N	N	N
Holcus lanatus	G	F	F	P	N	N	N	N
Hyparrhenia rufa	N	N	N	P	G	VG	VG	VG
Ixophorus unisetus	N	N	N	P	G	VG	VG	G
Lolium multiflorum	G	VG	G	P	N	N	N	N
Lolium perenne	F	VG	G	P	N	N	N	N
Melinus minutiflora	N	N	N	F	VG	F	G	F
Panicum antidotale	N	N	N	F	G	G	F	P
Panicum maximum	N	N	N	G	VG	VG	VG	VG
Panicum purpurascens	N	N	N	N	VG	VG	VG	VG
Paspalum conjugatum	N	N	N	F	G	G	G	G
Paspalum dilatatum	N	N	N	F	G	VG	VG	G
Paspalum notatum	N	N	N	G	G	VG	VG	G
Paspalum plicatulum	N	N	N	N	F	G	VG	F
Paspalum virgatum	N	N	N	F	G	G	G	G
Pennisetum ciliare	N	N	N	N	F	G	G	F
Pennisetum clandestinum	P	VG	VG	F	F	P	N	N
Pennisetum purpureum	N	N	F	F	VG	VG	VG	VG
Phalaris coerulescens	F	VG	G	F	P	N	N	N
Phalaris minor Retz.	F	G	G	P	N	N	N	N
P. tuberosa var. *stenoptera*	F	VG	G	P	P	N	N	N
Saccharum officinarum	N	N	N	F	G	VG	VG	VG
Sorghum sudanense	N	N	N	P	G	VG	VG	VG
Sorghum vulgare	N	N	N	P	G	VG	VG	VG
Tripsacum laxum	N	N	N	P	VG	VG	VG	VG

* The classifications (N = Not adapted, P = Poor, F = Fair, G = Good, and VG = Very good) indicate adaptation and relative production under optimum growing conditions.

downward. *Axonopus Micay* contributes a major portion of the pasture sward in the central area, which corresponds to the coffee growing region. Other grasses that appear outstanding and might become worthwhile pasture crops are pangola, coastal bermuda, and Dallis grass. Kikuyu *(Pennisetum clandestinum)* and Rhodes grass sometimes occur but are relatively unproductive. Imperial carpet grass *(Axonopus scoparius)* is the best adapted soiling crop for the central and upper areas and elephant grass *(Pennisetum purpureum)* and Guatemala grass *(Tripsacum laxum)* are best adapted to the lower areas. Sudangrass *(Sorghum sudanense)* and sorghum *(S. vulgare)* are also highly productive in the lower limits but are not in general use.

Alfalfa is well adapted to certain of the well drained soils of the warm climate but may require lime, phosphorus, and boron for establishment and maintenance. Potash and boron deficiencies in alfalfa have been observed after one year. Tropical kudzu is very productive in the lower areas and mixes well with para' or guinea grass or may be used alone. *Desmodium* spp. occur in almost all pastures and appear to contribute a noteworthy

FIGURE 3. Sudangrass and sorghum are well adapted to the warm climate and act as perennials under these conditions. They may be cut 5 to 8 times a year and yield 10 to 20 tons of green material per acre per cut. Tift sudangrass, *left;* common cattail millet, center; Starr millet, *right;* and forage sorghum in the background.

amount of forage to the pasture mixture. *Dolichos* spp. make luxuriant growth and could be used as a supplemental grazing or soiling crop but would probably be most useful as green manure. *Cajanus* spp. and velvetbeans are well adapted but are not generally used.

Cool Climate (6,500 - 10,000 feet)

Except for the Savannah of Bogota, the cool region is mountainous with precipitous slopes and small intervening valleys. The soils are rather high in organic matter (4-15 percent), have a low pH (4.5 - 5.5), and are deficient in phosphorus. The mean temperature is 55° F. and rains occur in three-month cycles.

The best adapted and most productive grasses are annual ryegrass *(Lolium multiflorum),* perennial ryegrass *(L. perenne),* orchardgrass *(Dactylis glomerata),* meadow fescue *(Festuca elatior),* tall fescue *(F. arundinacea),* rescue grass *(Bromus catharticus),* and kikuyu. The annual ryegrass produces the greatest quantity of forage in the early stages of growth but does not persist as well as the perennial form. Both are severely attacked by rust. Orchardgrass grows slowly for six months after establishment but later outyields perennial ryegrass. Kikuyu is the most widespread grass and occurs throughout the cool region. Velvet grass *(Holcus lanatus)* and sweet vernalgrass *(Anthoxanthum odoratum)* occur as weedy grasses in many pastures. Smooth brome *(Bromus inermis),* timothy *(Phleum pratense),* Kentucky bluegrass *(Poa pratensis),* redtop *(Agrostis alba),* tall oatgrass *(Arrhenatherum elatius),* reed canarygrass *(Phalaris arundinacea),* and Harding grass *(P. tuberosa* var. *stenoptera)* grow in the cool climate but are relatively unproductive. Common oats *(Avena sativa)* is suitable for use as a soiling crop but does not readily recover after cutting.

White clover *(Trifolium repens),* red clover *(T. pratense),* and alfalfa *(Medicago sativa)* are the most productive legumes in the cooler regions. White clover can be found in native pastures but a tremendous difference exists among types. In varietal trials certain ladino selections have yielded three and four times as much forage as the locally grown white clover varieties. Red clover and alfalfa have been more productive than white clover, but alfalfa is more exacting in its soil requirements. Other legumes that have been grown, although with less success, are Berseem clover *(Trifolium alexandrinum),* alsike clover *(T. hybridum),* hop clover *(T. procumbens),* bur clover

FIGURE 4. Common elephant grass is shown on the left and Napier elephant grass on the right. Napier elephant grass grows well in the warm climate, and may be cut 4 to 6 times a year, yielding from 20 to 40 tons of green material per acre per cut. At the extreme left is Guatemala grass, also a productive cutting crop.

Table 2. The relative adaptation of several species and selections of legumes in eight locations in Colombia, South America.*

Species	Usme 11,000 ft.	Bogotá 8,500 ft.	Las Palmas 8,000 ft.	Manizales 6,500 ft.	Medellín 4,500 ft.	Palmira 3,000 ft.	Villa-vicencio 1,500 ft.	Montería 150 ft.
Cajanus cajan	N	N	N	F	VG	VG	VG	VG
Calopogonium coeruleum	N	N	N	P	VG	VG	VG	VG
Calopogonium mucunoides	N	N	N	P	VG	VG	VG	VG
Centrosema plumieri	N	N	N	P	G	G	G	G
Centrosema pubescens	N	N	N	P	G	G	G	G
Clitoria ternatea	N	N	N	P	G	G	G	G
Crotalaria intermedia	N	N	N	P	G	G	G	G
Crotalaria juncea	N	N	N	P	VG	VG	VG	VG
Crotalaria paulina	N	N	N	P	VG	VG	VG	VG
Crotalaria striata	N	N	N	P	G	G	G	G
Desmodium spp.	N	N	N	F	G	VG	VG	VG
Dolichos lablab	N	N	N	P	VG	VG	VG	VG
Glycine max	N	N	N	P	VG	VG	VG	VG
Lathyrus tingitanus	P	VG	VG	G	P	P	P	N
Lupinus albus	G	G	G	F	P	P	N	N
Lupinus angustifolius	G	G	G	F	P	P	N	N
Lupinus luteus	G	G	G	F	P	P	N	N
Medicago hispida	P	G	G	F	N	N	N	N
Medicago sativa (Buffalo)	N	F	F	F	F	G	N	N
Medicago sativa (DuPuits)	N	VG	G	VG	G	G	N	N
Medicago sativa (Peruvian)	N	VG	G	VG	G	VG	N	N
Melilotus alba	P	VG	VG	VG	VG	G	G	P
Melilotus officinalis	P	G	G	G	G	F	F	P
Phaseolus angularis	N	N	N	P	G	VG	G	VG
Phaseolus calcaratus	N	N	N	P	VG	VG	VG	VG
Pueraria phaseoloides	N	N	N	P	VG	VG	VG	VG
Sesbania spp.	N	N	N	P	F	G	G	F
Stizolobium deeringianum	N	N	N	P	VG	VG	VG	VG
Trifolium alexandrinum	P	G	G	F	P	N	N	N
Trifolium pratense	F	VG	VG	G	F	N	N	N
Trifolium repens	F	VG	VG	F	P	N	N	N
Vicia spp.	F	VG	G	F	F	P	N	N
Vigna sinensis	N	N	N	N	VG	VG	VG	VG

* The classifications (N = Not adapted, P = Poor, F = Fair, G = Good, and VG = Very good) indicate adaptation and relative production under optimum growing conditions.

(Medicago hispida), black medic *(M. lupulina)*, birdsfoot trefoil *(Lotus corniculatus)*, lupines *(Lupinus* spp.), and vetches *(Vicia* spp.).

Cold Climate or Paramos (above 10,000 feet)

The region above 10,000 feet is largely mountainous with very small valleys. Many of the mountains extend above the timber line and several have snow-capped peaks. The soil is generally high in organic matter (10-20 percent), low in pH (4-5), and extremely low in phosphorus. The daily temperature ranges from 0° to 55° F.

The two most important grasses in the cold region are sweet vernal and velvet grass which cover most mountain slopes. Other genera which occur but are relatively unimportant are *Agrostis, Eragrostis, Calamagrostis, Stipa,* and *Sporobolus.*

Legumes are rarely found; however, native lupines and white and red clover grow in the lower fringes.

In Tables 1 and 2 are listed the species and several varieties or selections which proved to be superior in their regions of adaptation. The species that were not rated as good or better were omitted. Most varieties reacted in a similar manner to the species. The ratings given indicate adaptation as measured by persistence, desirable agronomic type, high forage yield (scored on a rating of leafiness, stemminess, height and spread), good seed setting ability, and rapid recovery after cutting. The scores show optimum yields as obtained under good management.

Summary

Grasses and legumes that occur in Colombia and introductions obtained from other sources were studied in observational nurseries located at elevations ranging from 150 to 11,000 feet above sea level. The nurseries contained 33 grass and 24 legume genera.

Data were recorded on habit of growth, height, spread, date

of flowering, relative seed set, relative forage yield, and recovery after cutting. Observations were made for 1½ or 2½ years.

The country was arbitrarily divided into four climatic zones: hot (0 - 2,500 feet), warm (2,500 - 6,500 feet), cool (6,500 - 10,000 feet), and cold (above 10,000 feet). The data compiled were used to rate the species according to adaptation within each zone.

The ratings measured persistence, desirable agronomic type, relative forage yield, seed production, and aftermath.