Early adoption of *Arachis pintoi* in the humid tropics: the case of dual-purpose livestock systems in Caquetá, Colombia

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Suggested page heading:

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Abstract

The early adoption of the legume *Arachis pintoi* was studied in the State of Caquetá, located in Colombia's Amazon region. Data came from 174 farmers randomly surveyed within the area of influence of Nestlé, a multinational milk-processing company. In addition, 52 farmers who had already adopted *Arachis* were surveyed separated to study their experiences, difficulties, and prospects with the legume. Results indicated that livestock activity is undergoing dynamic intensification. Since 1986, milk production per lactation has increased by 31%, cow fertility by 5%, herd size by 18%, and the area sown to improved pastures by 165%. Current adoption rate of *Arachis* is about 9.2%, with an estimated 3000 ha already planted. Two-thirds of farmers who had adopted *Arachis* said they would double, in the next year, the average area sown (9.6 ha/farm). Adopters tended to have larger farms and to have invested twice the capital than did non-adopters. The cost of seed for both grass and legume accounted for 40-52% of total establishment costs, making seed quality decisive in guaranteeing success. To promote *Arachis*, more information on the plant and its management in association with grasses must be disseminated. Mechanisms should also be sought to reduce establishment costs.

Introduction

Livestock activity in the State of Caquetá, located in the Amazon region of Colombia, South America, is mostly carried out by small and medium-scale farmers, who produce both beef and milk (ie., dual-purpose) in the same farm (Michelsen 1990). Cropping plays a marginal role. The bovine population is estimated at 1.1 million heads, equivalent to 4.2% of Colombia's livestock inventory (DANE 1996).

The State of Caquetá occupies an area of 8.9 million hectares, most of it under forest. The average annual rainfall is 3500 mm, with an annual relative humidity of 80.7%. Although livestock is the predominant agricultural activity, over the last two decades, illicit activities, such as planting and marketing coca, have become important sources of income, leading to deteriorated public order and social co-existence. One way of contributing to improved socioeconomic conditions is to increase income from livestock activities.

Reliable statistics to determine the evolution of milk production are not available, but information from Nestlé de Colombia (a branch of the multinational milk-processing company) shows that average annual sales of milk per farm to the company increased notably between 1986 and 1996, from about 8969 litres (l) to 14949 l.

As the human population in the region increased, the fresh milk market also grew and Nestlé was established, buying significant quantities of milk for processing and distribution at both local and national levels. This higher demand for milk induced farmers to increase production by improving the forage base of their farms, which contained a high degree of degraded native or naturalised pastures, with low production indexes per animal and per hectare. The adoption of the grass *Brachiaria*

decumbens marked a turning point in livestock production: dual-purpose cattle were raised, with emphasis on milk production (Michelsen 1990; Ramírez and Seré 1990).

For several years now, CIAT and Nestlé have jointly monitored the evolution of livestock systems in Caquetá in terms of two interrelated topics of common interest to both institutions: (1) the adoption of forage technologies, and (2) the production and productivity of livestock systems.

The forage legume *Arachis pintoi*, a perennial forage peanut, had already been developed through joint research between CIAT and its research partners. This material was evaluated for several years and was released in 1992 as a forage alternative for Colombia's *Altillanura* (hilly savannas), Coffee Region, and the Andean Piedmont (Rincón *et al.*1992).

The forage peanut is an innovative option for Caquetá because of its perennial and multiple purpose attributes. It has high potential for use in pastures, in mixtures with grasses or as cover crop. This legume, through nitrogen fixation and soil cover, can contribute significantly towards sustainable livestock systems.

The Nestlé Project, a collaborative effort between Nestlé and CIAT, was created to promote the adoption of *A. pintoi* in the region. The Project is oriented towards on-farm validation and transfer of this new technology. Most importantly, results from the Project were expected to be extrapolated to other regions of Colombia and tropical Latin America with similar environmental and socioeconomic conditions.

The adoption of new and improved forages is complex and slow. The decision to adopt an improved pasture implies a considerable investment of capital, not only to establish it but also to acquire more livestock because improved forages substantially

increase the stocking rate. This is a critical issue for small and medium-scale farmers, such as those predominating in Caquetá, who have limited capital and restricted access to credit.

For a new forage option to be massively adopted, it should be not only profitable, but also technically and financially viable. Furthermore, it must be sustainable in that it conserves the natural resources, that is, it should not cause or aggravate the deterioration of the productive capacity of natural resources over the long term.

The present study analyses the adoption process of *Arachis pintoi*, as promoted by the Nestlé Project. By using farmers as an information source, the Project was able to identify possible constraints to the process and thus facilitate the design of strategies to accelerate adoption.

A survey was conducted in 1997 of cattle farms of Caquetá that were located in Nestlé's area of influence to determine the current status of adoption of *A. pintoi*, albeit in a very early phase.

Materials and Methods

Basic data were collected by surveying a sample chosen from all the farms supplying milk to the Nestlé plant in Caquetá. A combined survey strategy was used, with two sample groups:

1. A completely randomised sample, whose size was determined through conventional statistical methods. Nestlé provided a list of farms supplying milk to its plant and the farms' daily and annual production during 1996. Using the

variance of farm milk production and assuming different levels of confidence and permissible margins of error, 174 farms were surveyed at random. The level of confidence was between 80 and 85%, with a permissible maximum error of the estimator (*i.e.* mean milk production per farm) of 10%.

2. Because the adoption of this technology is still very recent, the Project decided to make a further survey of 52 additional farms that were using the new material and thus gather information on farmers' experiences, difficulties and prospects with the legume.

In all, the survey interviewed 226 farmers, and covered the following topics: (1) current situation of pastures and constraints found in Caquetá; (2) farmers' use of *A. pintoi,* and knowledge of and expectations for the legume; (3) farm resources (availability of labour, land distribution and uses, and infrastructure); (4) specific farm characteristics; (5) institutional factors; and (6) economic indicators, such as prices of products and inputs.

Results and Discussion

Land use dynamics

Available data, when compared with data from a 1986 land use study (Ramírez and Seré 1990), show great dynamism in land use patterns in Caquetá (Tables 1 and 2). The most relevant aspects are:

- The relative importance of areas under natural and/or naturalised grasses, of very low productivity, has decreased, favouring a greater use of improved pastures.

- A wider diversity of forage germplasm is used, thus reducing the relative importance of *Brachiaria decumbens* and increasing the use of other species of *Brachiaria.* This is closely linked to spittlebug problems in the region.
- Compared with the 1986 situation, a modest increase of mixed grass/legume pastures can be observed, representing a new forage alternative for Caquetá.

The farmers are apparently responding to pest and disease problems by diversifying germplasm.

Current situation of pastures in the Caquetá region

Of the 226 farmers surveyed, 83% (187) acknowledged problems related to forage availability and quality, indicating a need for new technologies. Most of the problems perceived are related to diseases and pests, particularly spittlebug (Table 3) (Michelsen 1990; Ramírez and Seré 1990).

Use, knowledge and expectations for Arachis pintoi

Of the 226 farmers interviewed, a significant number (179) had heard of *Arachis*, 171 had seen it, and 68 were using it.

Farmers' experiences with forage peanut vary broadly, ranging from very recent plantings to grazing with different categories of cattle. *Arachis* is being planted in two types of pastures: (1) seedbeds, with an average size of 1.3 ha per farm; and (2) in association with grasses, with an average area of 9.6 ha. Of those farmers experimenting with forage peanut, 84% (57) use it in association with grasses, and 68% (39) have planted with sexual seed.

Of the 68 farmers who adopted the legume, 21 (31%) have had problems establishing it, mainly because of poor germination of the grass specie (8) and slow establishment of the forage peanut (7).

Overall, 82% of the 68 farmers were highly satisfied with *Arachis*, and 37 (55%) of them had already grazed Arachis, citing its capacity to increase pasture productivity. They also found that this forage increased stocking rate, milk production, and weight gains; controlled weeds; performed well in association with grasses; and enhanced palatability (Table 4).

Of the 23 farmers who have not yet used Arachis for grazing, 16 said that the legume had only been recently planted, 3 said it had not established well, 2 intended to use it for a different purpose, and 2 gave a mixture of the previous reasons.

Eight farmers who had tested the forage peanut were not satisfied with their results so far (Table 5).

Current status and prospects of adoption

Based on the random sample of 174 farmers, the current rate of adoption of forage peanut in Caquetá, expressed as the percentage of farmers using the material, is about 9%. At this rate, nearly 3000 ha are estimated to be planted to *A. pintoi* within Nestlé's area of influence (2973 farms). Of the total area planted, 2626 ha (88%) are planted to *A. pintoi* in association with grasses and the rest to *A. pintoi* alone.

Of the 68 "early adopters", 58 (85%) said they would be willing to expand the area planted to this legume. On average, they would increase the area planted by 11

ha/farm next year, by 10 ha the following year, and another 11 ha/farm within the next 3 years. Most (*i.e.* 47 of 58) would do so in association with grasses.

A high potential demand for sexual seed of forage peanut is foreseen, because 52% of the farmers who wanted to increase the area planted would use this type of seed. About one-fourth would use vegetative seed and 19% would use both types of seed (Figure 1).

Expectations and priorities of investment in cattle farms of Caquetá

A very high proportion of the interviewed farmers (95%) indicated that they would be willing to increase investment on the farm if they had access to additional capital. Most of these farmers (76.5%) live on the farm and derive their income exclusively from the livestock activity (87.3%). A major constraint to the adoption of improved pastures is the lack of capital. Pasture adoption requires two types of investments, the first in the establishment of new pastures. These, however, can carry a stocking rate that is double or triple of that supported by traditional technology, thus creating the need for an additional investment in cattle to adequately take advantage of the increased forage availability. The latter investment can be significantly higher, thus discouraging the adoption of new pastures.

To determine the investment priorities of farmers in Caquetá, they were asked what type of investment they would make should they have access to additional capital. Results indicated that 48% of available capital would be invested in livestock, followed by 25% in pasture improvement; 23% in infrastructure and equipment, and 4% in purchasing more land. Thus, farmers tend towards intensification through higher

stocking rates and improved pastures. The distribution of farmer priorities appears coherent because once improved pastures are established, investment in livestock is both complementary and indispensable to optimise the system as a whole.

These results are equally consistent with the region's land use dynamics, where the average farm size has varied relatively little, whereas production systems tend toward intensification by replacing naturalised pastures with improved pastures.

The grouping of cattle farmers' expectations of investment according to "early adopters" and "non-adopters" indicated that the former group tended to invest more in improved pastures, whereas the latter preferred to invest in livestock (Figure 2).

It is also important to emphasise that, although "early adopters" of forage peanut have, on the average, a larger area of improved pastures (in absolute terms) than do "non-adopters" (*i.e*. 153 ha versus 73 ha), "non-adopters" have, in relative terms, a slighter higher percentage of improved pasture than do "adopters" (*i.e.* 70% versus 67%).

Farm resources

About 80 to 90% of total investment found in livestock farms in the Latin American tropical lowlands are in land and livestock (Vera and Seré 1985; Seré 1986). In cattle ranches of Caquetá, the investments in land and livestock together accounted for about 77% of total investment in 1997, dropping from 82% in 1986 (Table 6).

Between 1986 and 1997, total investment increased in real terms by 80%. The largest increase was in infrastructure, increasing by almost 150%. Within this item, investment in fences increased notably, apparently indicating improved pasture

management by dividing and rotating paddocks. Investment per unit of used land increased by 49% and per head of cattle by 52%.

Notable differences were detected for the amount of total investment between the group of “early adopters” of *A. pintoi* and that of “non-adopters” (Table 7). Although the structure and level of investment per hectare and per cow in both groups are similar, the difference lies in the amount. In all categories, the absolute value of investment in adopting farms is double than that of “non-adopters”. These differences in capital use between the two groups of farmers may be an important factor in explaining and understanding the adoption of new technologies in the region.

Although livestock farms in this region are the main source of family income, the “early adopters” depend less on farm-generated income than do “non-adopters”. For “early adopters”, the farm accounts for 76% of total income, whereas for “non-adopters”, it accounts for 90%. To hypothesise, the “early adopters” have income from other sources and can therefore invest in technological improvement.

Production, productivity and gross income

The information obtained on annual beef and milk production in Caquetá indicates that, in 1997, the average farm in the region produced 19000 kg of milk and about 11000 kg of beef (liveweight). “Early adopters” more than doubled their production levels of both beef and milk compared with “non-adopters” (Table 8). Because the adoption of forage peanut is just beginning, its effect on current production levels is still insignificant. The previous figures simply show therefore the greater production scale of “adopters”.

Table 8 indicates that milk production in 1997 in farms of Caquetá accounted for almost 31% of total gross income. There is little difference between this figure and the 31.6% reported by Ramírez and Seré (1990) in 1986.

Farms adopting *A. pintoi* receive a higher gross return per unit of total capital, per hectare, and per head of cattle, suggesting a higher level of technology on these farms (Tables 9 and 10).

Between 1986 and 1997, several changes occurred on livestock farms of Caquetá that affected productivity in the region: (1) area under improved pastures increased at the expense of the area under naturalised pastures; (2) production per lactating cow increased; (3) calving rate rose slightly; and (4) production indicators and stocking rate per ha declined somewhat because of significant growth in area under improved pastures.

Although the area under improved pastures and production per cow increased substantially, the stocking rate and production per hectare did not, possibly reflecting the scarcity of livestock in the area. Many farmers do not have sufficient economic resources to make additional investments in livestock, once the new pastures are established. (Ramírez and Seré [1990] found that about 30% of livestock found in farms in Caquetá were co-owned by livestock funds[1] or with other farmers.) The improved pastures are therefore underutilised.

[1] Livestock funds are public companies which provide credit in the form of live cattle (ex., heifers, steers) and profits are distributed based on previous agreements between both parties

Technical and economic viability of technology based on A. pintoi

The *ex ante* evaluation of economic impact at the farm level clearly indicated that technologies based on the use of mixed pastures with *A. pintoi* are economically attractive because the internal rate of return is substantially greater than that of traditional monocropping (Table 11). However, although high and stable rates of return are a necessary condition, they are not sufficient to guarantee high adoption rates.

The majority of farmers testing the new material are satisfied with the results obtained so far, but several aspects are critical for the technical and economic viability of technologies based on *A. pintoi.*

First, the full financial implications of adopting this technology on a larger scale have not yet emerged. Farmers interviewed did not mention the high cost of establishment or the high price of *Arachis* seed as a reason for not adopting this type of technology, probably because they are still using *Arachis* in very small areas: seedbeds of 1.3 ha and associations with grasses averaging 9.6 ha.

These financial implications relate not only to the increase in establishment costs caused by the shift from traditional technology to improved technology but also to the increase in investment in cattle as a result of increased stocking rate.

Table 12 summarizes the information used to estimate indicators of marginal profitability of the technology being evaluated. By comparing a traditional technology in Caquetá, such as *Brachiaria* spp, with a new alternative, like *Brachiaria* associated with *Arachis* , the technological change increased establishment costs substantially, from US$152/ha (*B. decumbens* alone) to US$355/ha (*B. dictyoneura* + *A. pintoi*). In addition, the increase in stocking rate doubles the investment in livestock.

In Colombia, prevailing real interest rates in commercial banks are more than 14%. Therefore, new alternatives to provide credit must be found, perhaps similar to livestock funds, that could finance the establishment costs of improved pastures so necessary for modernizing livestock systems.

The cost of seed is the second critical aspect because it represents a very important fraction of the establishment cost. For example, in the case of associated pastures, seed represents 40 to 52% of total establishment costs, depending on the type of grass used (Rivas and Holmann 1996).

Seed quality is decisive in the successful establishment of new forage alternatives. In those cases where the association has failed to establish itself, the farmers interviewed attributed the failure to low germination of the grass seed. Grass seed in the area varies widely, in both quality and price.

A fourth high-risk factor for the persistence of associated pastures in Caquetá is the prevalence of spittlebug, which not only makes pasture management difficult but also complicates the maintenance of adequate grass-to-legume proportions to ensure that the technology is sustainable, productive and profitable.

Commercial *A. pintoi* seed marketed in Caquetá is considered as being of high quality in terms of purity and germination. However, local prices are much higher than those of neighbouring countries, like Bolivia. The local price per kilogram in the region ranges between $20 and $25/kg; in contrast, Bolivian seed placed in Colombia costs no more than $15/kg. Ways of locally producing cheap high-quality *A. pintoi* seed must be found.

Despite the attributes of *A. pintoi*–high productivity, forage quality, and perennial nature–its seed cost substantially more than that of other forage legumes used in the region, such as *Pueraria phaseoloides* (kudzu), *Centrosema macrocarpum* or *Desmodium ovalifolium*, which cost between $12 and $15/kg.

Under the circumstances of the farmers' reduced economic capacity and limited knowledge, formulas are needed to accelerate the adoption of *Arachis*, not only by reducing establishment costs but also by seeking ways of financing these costs. Information on the use, management and potential of *A. pintoi* should also be widely disseminated in Caquetá.

Conclusions and Recommendations

Results from this study leads us to make the following conclusions and recommendations:

1. The dual-purpose production system is found on 87% of farms and concentrates 86% of the region's total area in improved pastures.
2. Most farmers (83%) in Caquetá have problems with diseases and pests, particularly the widespread spittlebug, attacking their pastures, especially grasses. A high potential demand therefore exists for new forage materials which are more persistent and productive.
3. In response to this situation, forage germplasm and pasture composition in Caquetá have diversified notably. Improved pastures are rapidly replacing native pastures, increasing from 26% of the total farm area in 1986 to 58% in 1997.

4. Between 1986 and 1997, milk production per cow per lactation increased by 31%, calving rate by 5%, and herd size by 18%.
5. At present, farms are underinvesting in livestock, because, although the area under improved pastures (which are capable of maintaining a higher stocking rate) has increased substantially, total stocking rate has decreased.
6. The average stocking rate (heads/ha) decreased by 13% over the two periods of observation because the total area under pasture grew 21%, while the livestock inventory increased by only 18%. It would seem logical that farmers have, as first priority, investment in purchasing animals.
7. The adoption of *A. pintoi* in Caquetá is just beginning. Farmers who currently use *Arachis* do so in small areas to obtain experience about its establishment, use and management. This phase is known in the literature as “early adoption”, which, in the case of pastures, takes much longer than annual crops because the adoption of new pastures implies a decision to invest heavily over long periods of time. Farmers are thus very careful when evaluating new forage options before planting on a large scale.
8. Most “early adopters” of *A. pintoi* (82%) were satisfied with the results they had obtained so far. The average area planted per farm was 9.6 ha to *Arachis* associated with grasses and 1.3 ha in seedbeds. Of these “adopters”, 85% said they would expand the areas planted to *Arachis* by an average of 11 ha/farm the following year, 10 ha the next year, and, within 3 years, another 11 ha/farm.
9. The current adoption rate of *Arachis* is about 9.2%. Estimates indicate that 3000 ha are planted to this legume, mainly in association with grasses.

10. Farmers who are “early adopters” of *Arachis* tend to be wealthierr than those who are “non-adopters”, that is, they have larger farms, invest more, and have twice the capital. Being wealthier encourages “adopters” to invest more in new technologies.
11. “Early adopters” are also less dependent on farm income than are “non-adopters”; their farms contribute 76% of total income in contrast to 90% for “non-adopters”. “Early adopters” are thus more willing to invest in new technologies.
12. The areas planted to the new material are small, representing less than 10% of total area in pastures. Farmers may not yet be aware of the problem of financial viability that may result from large-scale use of *A. pintoi*. During interviews, farmers did not mention seed price or establishment cost as obstacles for adoption.
13. Previous economic studies have demonstrated that establishment costs increase considerably when a traditional *Brachiaria* pasture is replaced by an associated pasture with *A. pintoi.* Financial problems may therefore occur when large extensions of mixed grasses with *Arachis* are established, especially in the case of small farmers.
14. Because of the high establishment costs of associated pastures and the limited capital of small farmers, new financing mechanisms must be sought, not only for pasture establishment but also for purchasing livestock to facilitate adoption.
15. The cost of grass + legume seed accounts for 40-52% of total investment in establishing associated pastures. As a result, the quality of legume and grass seed is decisive for minimizing the risk of failure in pasture establishment and for ensuring successful investment.

16. Farmers need more information on the use, management, production and environmental potential of *A. pintoi*. Most interviewees (70%) said they had not received any type of technical assistance. The remaining 30% had received assistance in the areas of animal management and health. Technical assistance in nutrition, management and establishment of improved and associated pastures is practically nonexistent.
17. To better understand the adoption of new pastures, the different phases of adoption should be monitored to identify, on a timely basis, constraints, provide feedback for research systems and policymakers, and obtain basic information needed for subsequent *ex post* studies of socioeconomic impact.
18. Very few institutions conduct studies that evaluate the adoption of agricultural technologies and, in the area of adoption of new pastures, the gap is even more noticeable. Although these studies are time-consuming and expensive, frequent follow-ups (*i.e.* every 3 years) are desirable because, as mentioned before, timely adjustments can then be made to the technology and policies can be suggested that favour high adoption rates. These studies enhance the possibility of technological development having a significant and favourable impact on society and environment, which is the main reason to invest resources in the generation and development of new technologies.
19. Economic and social stability is fundamental for consolidating technological adoption in rural areas, which, in recent years, have been exposed to frequent social conflicts and pressures of diverse nature. This situation has, in some way, influenced farmers' decisions on investing in the region and on adopting

technological developments. In the future, adoption and investment will largely depend on the successful search of agreements and mechanisms that will improve civilian co-existence and social order in this vast region of Colombia.

Acknowledgements

The authors would like to especially thank Nestlé de Colombia for the logistic support provided during the preparation and execution of the survey, and for partially funding the processing and analysis of survey results.

References

DANE (Departamento Administrativo Nacional de Estadística) (1996) *Encuesta Nacional Agropecuaria; Resultados 1995.* (Departamento Administrativo Nacional de Estadística, Dirección General del Sistema de Información Nacional y Territorial: Santafé de Bogotá, Colombia).

MICHELSEN, H. (1990) *Análisis del desarrollo de la producción de leche en la zona tropical húmeda: El caso del Caquetá, Colombia.* Working document no. 60. (CIAT: Cali, Colombia).

RAMÍREZ, A. and SERÉ, C. (1990) *Brachiaria decumbens* en el Caquetá: Adopción y uso en ganaderías de doble propósito. *Proyecto colaborativo Nestlé de Colombia, Fondo Ganadero del Valle, INCORA, SENA, Universidad del Amazonas, ICA, CIAT.* Working document no. 67. (CIAT: Cali, Colombia).

RINCÓN, A.C., CUESTA, P.A., PÉREZ, R., LASCANO, C.E., and FERGUSON, J. (1992) *Maní forrajero perenne (*Arachis pintoi *Krapovickas & Gregory): Una alternativa para agricultores y ganaderos*. Boletín técnico no. 219. (ICA and CIAT: Cali, Colombia).

RIVAS, L. and SERÉ, C. (1985) Price and supply seasonality of beef in Colombia–Implications for the role of improved pastures. In:*Trends in CIAT Commodities*. Internal Document Economics 1.10, MAY. (CIAT: Cali, Colombia).

RIVAS, L. and HOLMANN, F. (1996) *Análisis económico de nuevas alternativas de pasturas asociadas basadas en la leguminosa* A. pintoi *en Caquetá, Colombia.* (CIAT: Cali, Colombia). (Typescript).

SERÉ, C. (1986) Socioeconomía de la producción bovina de doble propósito. In: *Panorama de la ganadería de doble propósito en la América tropical.* (ICA and CIAT: Santafé de Bogotá, Colombia).

SERÉ, C. and VACCARO, L. (1985) Milk production from dual–purpose systems in tropical Latin America. In: *Milk production in developing countries.* (University of Edinburgh: Scotland).

VERA, R. and SERÉ, C. 1985. *Sistemas de producción pecuaria extensiva: Brasil, Colombia y Venezuela, Informe Final Proyecto ETES.* (CIAT: Cali, Colombia).

Table 1. Land use dynamics on dual-purpose farms in Caquetá, Colombia (1986 and 1997).

Land use	1986 survey[1]		1997survey	
	Area (ha)	%	Area (ha)	%
Total farm area	131	100	158	100
Pasture area	95	73	129	82
- Naturalised	62	47	38	24
- Improved	33	26	91	58
Cropping area	4	3	3	2
Fallow area	22	17	10	6
Forest area	9	7	16	10

[1]Data from Ramírez and Seré (1990).

Table 2. Frequency of use of pastures on cattle farms located in Caquetá, Colombia (1986 and 1997).

Type of pasture	1997			1986		
	Frequency of use		Total area (ha)	Frequency of use		Total area (ha)
	Absolute (no. of farms)	Relative (%)		Absolute (no. of farms)	Relative (%)	
Naturalised	200	89.7	8505.3	117	99.2	7304.2
Brachiaria decumbens	182	81.6	13111.5	110	93.2	3056.2
B. humidicola	86	38.6	2823.3	5	4.2	23.6
Arachis pintoi in association	57	25.6	546.6	0	0.0	0.0
B. brizantha	55	24.7	954.5	0	0.0	0.0
Pangola grass	52	23.3	2419.5	50	42.4	153.4
B. dictyoneura	22	9.9	196.0	0	0.0	0.0
A. pintoi alone	8	3.6	10.1	0	0.0	0.0
Imperial grass	5	2.2	137.0	9	7.6	200.6
B. ruziziensis	5	2.2	21.0	0	0.0	0.0
Jaragua grass	4	1.8	61.0	18	15.3	318.6
B. decumbens and *Desmodium* sp.	2	0.9	7.0	0	0.0	0.0
Buffel grass	2	0.9	31.0	0	0.0	0.0
B. humidicola and *B. decumbens*	1	0.4	30.0	0	0.0	0.0
B. dictyoneura + *B. brizantha* + *B. decumbens*	1	0.4	6.0	0	0.0	0.0
B. humidicola + *B. dictyoneura*	1	0.4	2.0	0	0.0	0.0
B. decumbens + *B. brizantha*	1	0.4	10.0	0	0.0	0.0
B. brizantha + *Desmodium* sp.	1	0.4	4.0	0	0.0	0.0
Other *Brachiaria* species[1]	9	4.0	72.0	0	0.0	0.0
India grass	1	0.4	8.0	0	0.0	0.0
Kudzu	1	0.4	30.0	0	0.0	0.0
Axonopus micay	0	0.0	0.0	7	5.9	47.2
Panicum maximum	0	0.0	0.0	5	4.2	82.8
Para grass	0	0.0	0.0	11	9.3	47.2
Elephant grass	0	0.0	0.0	1	0.8	94.4
Total no. of farms in sample	223			118		

[1]Includes *B. radicans* and *B. plantigea,* both known in the area as “brachipará”.

Table 3. Frequency of problems limiting forage production on farms located in Caquetá, Colombia.

Type of problem	Farmers	
	(no.)[1]	(%)
Pests and diseases	146	64.6
Poor quality of available forage	60	26.5
Problems related to climate (rain, drought)	24	10.6
Lack of physical and financial resources	8	3.5
Lack of other forage options	3	1.3
Problems related to soil quality	5	2.2
Others	3	1.3

[1]The total number of farmers is greater than 226 because some farmers reported more than one problem.

Table 4. Farmers' opinions of *Arachis pintoi* as a grazed forage legume, Caquetá, Colombia (1997).

Score	Farmers	
	(no.)	(%)
Very good	10	26.3
Good	19	50.0
Regular	4	10.5
Bad	1	0.6
Don't know yet	4	1.5
Total	**38**	**100.0**

Table 5. Causes for dissatisfaction among farmers who had tested *Arachis pintoi* in Caquetá, Colombia (1997).

Cause for dissatisfaction	Farmers	
	(no.)	(%)
Not yet identified	4	50.0
No progress observed	2	25.0
Cattle won't consume it	1	12.5
Tends to disappear	1	12.5
Total	**8**	**100.0**

Table 6. Evolution and composition of investments in cattle farms of Caquetá, Colombia (in constant US dollars, 1997).

Investment	1986			1997			Variation
	Mean	Value	%	Mean	Value	%	1986-1997 (%)
Land (ha)	130.9	35069	36.1	157.8	75744	31.4	+116.0
Heads of cattle	121.2	44495	45.8	143.0	59774	39.0	+34.3
Infrastructure			15.8			27.6	+141.8
Corrals (m^2)	*300.0*	*2203*	*2.3*	*231.0*	*1696*	*1.3*	*-23.0*
Fences (km)	*4.3*	*5367*	*5.5*	*21.8*	*27211*	*20.2*	*+407.0*
House (m^2)	*150.0*	*5507*	*5.7*	*146.0*	*5360*	*4.1*	*-2.7*
Equipment		*2555*	*2.3*		*2659*	*2.0*	*+4.1*
Total		97451	100.0		175250	100.0	+79.8
Investment/ha		744			1111		+49.3
Investment/head of cattle		804			1226		+52.5

Table 7. Value and composition of investments in cattle farms of Caquetá, Colombia (in US$ of 1997), compared between early and non-adopters of *Arachis pintoi*.

Investment category	Early adopters			Non-adopters			Adopter/non-adopter investment ratio
	Average	Value	%	Average	Value	%	
Land (ha)	277.0	132960	33.2	123.0	59040	31.4	2.3
Heads of cattle	232	96976	38.1	117	48906	41.0	2.0
Infrastructure			26.8			25.5	2.2
Corrals (m^2)	*375.0*	*2752*	*1.2*	*189.0*	*1338*	*1.3*	
Fences (km)	*38.3*	*47765*	*21.4*	*17.0*	*21210*	*20.2*	
House (m^2)	*256.3*	*9408*	*4.2*	*113.8*	*4178*	*4.0*	
Equipment		*4,314*	*1.9*		*2176*	*2.1*	*2.0*
Total		294176	100.0		136897	100.0	2.1
Investment/ha		1062			1113		
Investment/head		1268			1170		

Table 8. Levels of production, gross income and proportion of income from milk of dual-purpose farms in Caquetá, Colombia, during 1997.

Item[1]	Prices[1]	Adopters	Non-adopters	Total average
Annual milk production (litres/farm)	0.21/kg	33752	14594.8	19002.8
Gross income from milk sales (US$)		7108	3074	4402
Number of animals sold each year				
Calves	US$152/head	34	10	15
Culled cows	US$275/head	16	7	9
Fattened steers	US$430/head	21	10	13
Gross income from sale of livestock (US$)		18602	7748	10348
Total gross income (US$)		25710	10822	14350
Gross income per hectare (US$)		93	88	91
Gross income per head of cattle (US$)		111	92	101
Proportion of income from milk (%)		27.6	28.4	27.9
Number of farms		68	158	226

[1]Monetary values are expressed in US$ of 1997.

Table 9. Evolution of productivity indicators of cattle farms in Caquetá, Colombia (n = number of farms).

Indicators	1986 (n=118)	1997 (n=226)	Change (%)
Calving rate (%)	61.2	64.5	5
Calf mortality (%)	9.5	11.0	15
Adult mortality (%)	2.7	3.6	33
Extraction rate (%)	17.3	18.6	7
Stocking rate (heads/ha)	1.27	1.11	-13
Production/cow per lactation (litres, l)	577	760.1	31
Production/cow per day of lactation (l)	2.4	3.2	31
Production/hectare of pasture (l)	156.7	147.3	-6
Area under improved pastures (ha)	34.1	90.4	165
Total inventory (heads)	121	43	18
Inventory of cows (heads)	49	58	18
Proportion of natural pastures (%)	65	29.5	-54
Meat production/hectare (kg)	149.6	87.2	-41
Meat production/head (kg)	106.3	78.2	-26
Average farm size (ha)	130.5	157.8	20

Table 10. Productivity indicators in groups of "early adopters" and "non-adopters" of *Arachis pintoi* in cattle farms of Caquetá, Colombia, 1997. (n = number of farms.)

Indicators	Adopters (n=68)	Non-adopters (n=158)	Average (n=226)
Calving rate (%)	67.9	63.5	64.5
Calf mortality (%)	12.0	10.8	11.0
Adult mortality (%)	3.6	3.7	3.6
Culled cows (%)	14.6	13.7	13.9
Extraction rate (%)[1]	24.7	15.2	18.6
Stocking rate (heads/ha)	1.02	1.17	1.11
Production/cow per lactation (litres, l)	865.4	663.4	760.1
Production/cow per day of lactation (l)	3.6	2.8	3.2
Area under improved pastures (ha)	153	73	90.4
Total inventory (heads)	232	117	144.0
Milking cows (heads)	39	22	25
Area of pastures at breeding sites (%)	32.9	27.3	29.5
Meat production/hectare (kg)	90.2	84.3	87.3
Meat production/head (kg)	88.6	72.2	78.2
Average farm size (ha)	277	123.2	157.8

[1]Excludes fattened steers.

Table 11. Internal Rate of Return from associations of *Arachis pintoi* with different *Brachiaria* species in Caquetá, Colombia, during 1996.[1]

Type of pasture	Establishment costs ($/ha)	Milk production (l/cow per day)	Stocking rate (AU/ha)	Internal rate of return (%)
B. decumbens alone	152	3.0	1.0	12.0
B. decumbens + *A. pintoi*	272	3.5	1.5	19.3
B. humidicola + *A. pintoi*	325	3.5	2.0	21.8
B. dictyoneura + *A. pintoi*	355	3.5	2.0	21.1

[1]Rivas and Holmann (1996).

Table 12. Basic economic and biological information for analysis of the marginal profitability of forage alternatives in Caquetá, Colombia, during 1996.[1]

Variables	Bd alone	Bd + Ap	Bdict + Ap	Bh + Ap
Establishment costs (US$/ha)	152	272	355	325
Production/cow (l/day)	3.0	3.5	3.5	3.5
Farmgate price of milk (US$/l)	0.22	0.22	0.22	0.22
Stocking rate (AU/ha)	1	1.5	2	2
Price of land (US$/ha)	290	290	290	290
Price per animal (US$)				
Milking cow	482	482	482	482
Culled cow	338	338	338	338
Weaned calf	174	174	174	174
Duration of lactation (days)	240	240	240	240
Calving rate (%)	60	60	60	60
Evaluation period (years)	12	12	12	12
Daily wage (US$/day)	7.7	7.7	7.7	7.7
Cost of resowing (US$/ha)	38	68	89	81
Frequency (years)	4	4	4	4

[1]Data from Rivas and Holmann (1996).

Bd = *Brachiaria decumbens*; Bdict = *B. dictyoneura*; Bh = *B. humidicola*; Ap = *Arachis pintoi*.

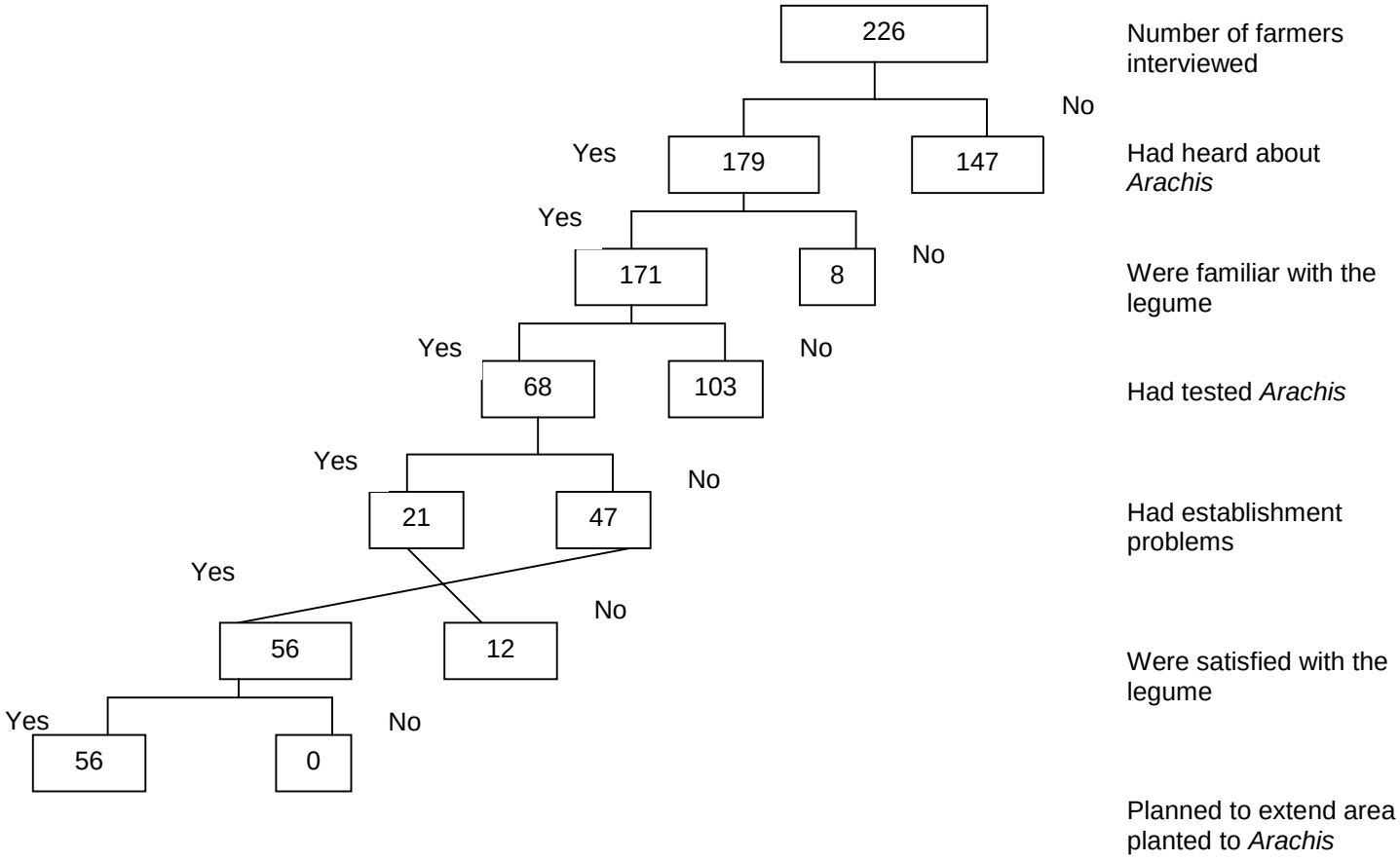

Figure 1. Sequences in the early adoption of *Arachis pintoi* by farmers in Caqueta, Colombia.

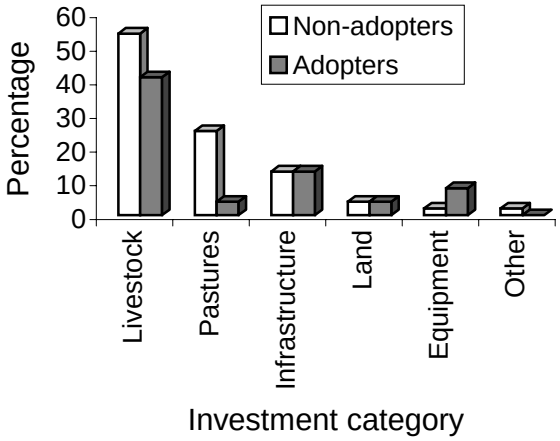

Figure 2. Expected distribution of additional capital by type of farmer, showing investment priorities of owners of dual-purpose cattle farms in Caquetá, Colombia