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PRACTICAL TECHNOLOGIES FOR THE IMPROVEMENT OF PASTURES IN CENTRAL AMERICA

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The Atlantic Zone Programme (CATIE-AUW-MAG) is the result of an agreement for technical cooperation between the Centro Agronómico Tropical de Investigación y Enseñanza (CATIE), the Agricultural University Wageningen (AUW). The Netherlands and the Ministerio de Agricultura y Ganadería (MAG) of Costa Rica. The Programme, that was started in April 1986, has a long-term objective multidisciplinary research aimed at rational use of the natural resources in the Atlantic Zone of Costa Rica with emphasis on the small landowner.

Location of the study area.

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PRACTICAL TECHNOLOGIES FOR THE IMPROVEMENT OF PASTURES IN CENTRAL AMERICA

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Summary

Animal production in tropical regions has lagged behind plant production and the main reason is that there has been little application of forage production improvement. For all but the (semi-)arid regions technology is available for forage production improvement for the different animal production systems, ranging from intensive dairying to extensive ranching. The key to improvement is the use of legumes with minimal fertiliser inputs.

The adoption of forage production improvement depends on the need for improvement, the value and marketability of animal products, the motivation of farmers and the availability of resources.

Sustainability of improved pastures is mainly a function of the persistence of the legumes. This in turn depends on the growth habit of the plant and management. Trailing species are most sensitive to high grazing pressure, whilst prostrate species are the most tolerant. Erect species take an intermediate position.

Introduction

Production of food in tropical regions has risen dramatically in the last two decades as a result of the green revolution, which consisted of an intensification of production with increased inputs, such as fertilisers, improved cultivars and crop protection. The tropical pasture revolution hailed in the 1960's has also resulted in highly increased potential production of livestock products. However, production improvement has been more obvious in the crop than in the livestock sector. This can be attributed to many factors. Firstly, there is greater need for staple foods, such as rice, than for food of animal origin, secondly there are more ready markets for certain cash crops than for animal products and thirdly livestock production is often carried out in drier areas and on poorer soils.

Available technology and its application

Tropical pasture technology aims to improve animal production through the use of pasture improvement based on the input of resources in accordance with the prevailing economic conditions.

Forage production improvement can be carried out 1) by establishing grass pastures to be fertilised with NPK, 2) by establishing grass-legume mixtures, 3) by oversowing legumes into existing pastures, 4) by establishing monocultures of legumes (protein banks) and 5) by establishing fodder crops. The use of fertilisers on legume based pastures would consist of P and rarely K and trace elements. For intensive production systems on poor soils fertilisation would materially increase the yield and persistence of pastures and it would be a good return on investments. Grasses are more difficult to establish and are less persistent without fertiliser (particularly N) than legumes, although some legumes will not persist on poor soil without P and trace element fertiliser. However, in many situations fertilisation is not possible, because of the low return from animal products, in which case legumes such as Stylosanthes species can be selected which can produce and persist at low fertility levels. It makes a big difference also whether the forage is grazed or cut and removed. In the first case nutrients are returned, albeit very unevenly, but in the case of cutting the nutrients are removed with the forage and usually not returned, because the dung (and urine) is used for other purposes (fuel, manure for food crops). For example, a crop of Pennisetum purpureum, can yield 30 tons/ha of dry matter. When this is cut and removed, this means the removal per ha of some 600 kg of nitrogen, 60 kg of phosphorus and 900 kg of K. Therefore, repeatedly cut forage depletes soil fertility rapidly and fertilisation is necessary for sustainable production.

Which is the most appropriate method of pasture improvement depends on the intensity and the objective of the production system. Dairy production for the liquid milk market, with assured income and high requirements for quality feed, will apply more intensive production methods than beef production in remote regions which has to rely on export of low quality beef with uncertain prospects for the future. The dairy farmer is more likely to base production on grass plus full fertilisation and/or grass legume pastures with fertilisers, whereas the beef producer, if he thinks of pasture improvement at all, would possibly oversow legumes into native pastures without fertilisation.

Selected grasses and legumes have become available at a rapid rate since the 1960's for all tropical and subtropical regions except the (semi-)arid ones (Henzell and 't Mannetje 1980, 't Mannetje 1984). Table 1 lists the main grasses and legumes for different climatic zones as defined by Troll (1966):

1) tropical rainy climates with 12 to 9.5 humid months (zone V_1)
2) tropical humid-summer climates with 9.5 to 7 humid months (V_2)
3) wet and dry tropical climates with 7 to 4.5 humid months (V_3)
4) permanently humid climates with hot summers and maximum rainfall in the summer (IV_7)
5) climates with 9 to 6 humid summer months and dry winter (IV_4)

The main requirements of forage species are that they must be adapted to the prevailing climatic and edaphic conditions, that they are grazing tolerant, disease and pest resistant, free of harmful constituents and tolerant to low fertility. It is not possible to find species to which all these requirements apply.

Table 1. Selected grasses and legumes for pasture improvement in four climatic regions as defined by Troll (1966) ('t Mannetje and Jones 1989)

GRASSES	CLIMATIC ZONES V_1&V_2	V_3	IV_7	IV_4
Andropogon gayanus	x	x	-	-
Brachiaria brizantha	x	x	-	-
Brachiaria decumbens	x	x	-	-
Brachiaria dictyoneura	x	x	-	-
Brachiaria humidicola	x	x	-	-
Brachiaria mutica	x	x	-	-
Brachiaria ruziziensis	x	x	-	-
Cenchrus ciliaris	-	x	-	x
Chloris gayana	-	x	x	x
Cynodon dactylon	x	x	x	-
Cynodon nlemfuensis	x	x	-	-
Digitaria decumbens	x	x	x	-
Digitaria setivalva	x	x	-	-
Panicum maximum	x	x	-	-
Panicum maximum var. trichoglume	-	-	x	x
Paspalum dilatatum	-	-	x	-
Paspalum plicatulum	x	x	x	-
Pennisetum clandestinum	-	-	x	-
Pennisetum purpureum	x	x	-	-
Setaria sphacelata	x	x	x	-
Sorghum almum	-	-	-	x
Sorghum sudanense	x	x	x	x
Tripsacum laxum	x	-	-	-
Urochloa mosambicensis	-	x	-	-
Zea mays	x	x	x	-
SHRUB LEGUMES				
Albizia lebbeck	-	x	-	x
Calliandra calothyrsus	x	-	-	-
Codariocalyx gyroides	-	x	x	-
Flemingia macrophylla	x	-	-	-
Gliricidia sepium	x	-	-	-
Leucaena leucocephala	x	x	x	x
Sesbania grandiflora	x	-	-	-
Sesbania sesban	x	-	-	-

Table 1 (ctd).

	CLIMATIC ZONES			
	V_1&V_2	V_3	IV_7	IV_4
HERBACEOUS LEGUMES				
Aeschynomene americana	x	-	x	-
Aeschynomene falcata	-	-	x	x
Alysicarpus vaginalis	x	x	-	-
Arachis pintoi	x	x	-	-
Calopogonium mucunoides	x	x	-	-
Cassia rotundifolia	-	x	-	x
Centrosema acutifolia	x	x	-	-
Centrosema macrocarpum	x	x	-	-
Centrosema pascuorum	-	x	-	-
Centrosema pubescens	x	x	-	-
Clitoria ternatea	-	x	-	-
Desmodium heterocarpum	x	x	x	-
Desmodium heterophyllum	x	x	-	-
Desmodium intortum	-	-	x	-
Desmodium ovalifolium	x	x	x	-
Desmodium triflorum	x	-	-	-
Desmodium uncinatum	-	-	x	-
Lablab purpureus	x	x	x	x
Lotononis bainesii	-	-	x	-
Macroptilium atropurpureum	-	x	x	x
Macroptilium lathyroides	-	x	x	x
Macrotylome axillare	-	x	x	x
Medicago sativa	-	-	x	x
Neonotonia wightii	-	-	x	-
Stylosanthes capitata	x	x	-	-
Stylosanthes hamata cv. Verano	-	x	-	x
Stylosanthes humulis	-	x	-	x
Stylosanthes guianensis	x	x	x	x
Stylosanthes macrocephala	x	-	-	-
Stylosanthes scabra	-	x	-	x
Trifolium repens	-	-	x	-
Trifolium semipilosum	-	-	x	-
Vigna parkeri	-	-	x	-
Vigna unguiculata	x	x	-	x

Management can make up for species' shortcomings. For example, legumes which have a low grazing tolerance should either be replaced by those that do possess it, or should be grazed intermittently. Another example is the mimosine content of Leucaena leucocephala, which need not be a problem to animal health so long as the animal's diet does not exceed 30 % of Leucaena for more than six months. On the other hand, it is also possible to infuse the rumen of susceptible animals with micro-flora from non-susceptible animals, which can break down the toxic derivative of mimosine (DHP) (Jones and Megarrity 1986).

Not all species need to be tolerant to low fertility, because fertilisers can be used in certain production systems.

The application of pasture technology

The application of pasture improvement in existing farm systems is governed by the following conditions:
1. the need for improved animal production
2. the value and marketability of animal products
3. the motivation of farmers
4. the availability of resources

1. The need for improved animal production.

Animal proteins play an important role in the human diet and in most developing countries there is a need for more and better food. Ruminants are able to produce food and especially proteins on land which is otherwise of little use for food production.

When comparing the distribution of people, farm animals and the production of meat and milk in temperate (mostly developed) and tropical (mostly developing) countries, it is clear that tropical countries lag behind (table 2). Although far more animals are kept in tropical than in temperate countries, the production of meat and milk in the tropics is only 36 and 18 %, respectively, of the total world production. This is due to inadequate nutrition, health care and management of the animals. Therefore, if animal production is to be increased, the feed supply of the animals needs to be improved. Since animal feed comes mostly from forages, it is evident that forage production and quality need to be improved.

Table 2. Distribution of farm animals, people, production of meat and milk (source FAO Yearbooks)

	% in developed countries	% in developing
Cattle	36	64
Buffaloes	--	100
Sheep	49	51
Goats	6	94
Pigs	40	60
People	25	75
Milk production	82	18
Meat production	64	36
Kg milk/person	320	23
Kg meat/person	54	11

By oversowing a legume into native pasture, or by establishing grass-legume pastures big improvements in animal production can be obtained. Edye and Gillard (1985) reported that by oversowing *Stylosanthes hamata* cv. Verano into the native pasture, with the use of phosphate fertiliser, in northern Australia, the carrying capacity could be increased up to ten-fold and cattle fattened in about half the time when compared with native pastures.

In an experiment at the Narayen Research Station in south-east Queensland, with 700 mm average annual rainfall and a dry season of about 5 to 6 months and light frosts during the dry season, three herds of breeding cows were used to measure beef production on unimproved native pasture at a stocking rate of 0.17 cows/ha and sown grass-legume pasture with superphosphate at stocking rates of 0.50 and 0.68 cows/ha over a period of ten years (Coates and ´t Mannetje 1990). A summary of the results is given in table 3.

Table 3. Mean conception and calving rates, average daily gain of calves, weaning weight at 7 months of age, weight of calf per cow mated and weight of calf per ha on unimproved native pasture and sown grass-legume pasture in south-east Queensland.

	Native pasture	Grass-legume pasture
Conception rate	84 %	90 %
Calving rate	79 %	82 %
Average daily gain calves	0.78 kg	0.92 kg
Weaning weight	200 kg	241 kg
Weight of calf/cow mated	155 kg	199 kg
Weight of calf/ha	26 kg	118 kg

On both treatments conception and calving rates were high, but the long term average calving percentage of commercial beef production in the region on native pastures of 70 - 75 % is also considerably higher than the Queensland state average (c. 60 %). All production parameters on sown pasture were higher than on native pasture. The results are most strikingly presented in terms of production per ha. Sown pasture produced 4.5 times more weight of calves per ha than native pasture and they were 20 % heavier. At the same research station, ´t Mannetje and Jones (1990) showed an increase in beef production from pasture improvement with *Cenchrus ciliaris* and *Macroptilium atropurpureum* of 5 times compared to native pasture over a period of ten years.

Even on improved tropical pastures milk production never exceeds 15 kg milk/cow/day without the use of concentrates, because of the limited quality of tropical forages for milk production, and usually it is less than 10 kg; on unimproved grasslands, production is very low (3-5 kg milk/cow/day) (Stobbs and Thompson 1975).

2. The value and marketability of animal products

Subsistence producers with only incidental access to markets are unlikely to have excess to finance for pasture improvement.

Larger scale producers are by definition dependent on markets for their outputs. Prices on local, national and international markets will be determined by the ratio of supply and demand. The local demand in turn depends on consumers' incomes. Markets for milk are readily available in regions close to large population centres or where butter and cheese factories are present. Beef markets can be divided into local and export markets. Particularly export markets tend to be variable in size and prices can vary considerably from year to year. This gives uncertainty of income for producers and has a negative effect on the willingness to make investments into pasture improvement.

3. The motivation of farmers

A very important consideration of the producer who is willing to go in for pasture improvement is the cost and the expected return on investment. Costs are high and it depends on the financial situation of the farm whether it would be attractive to apply the technology. Although eventually a high return may be achieved, during the first few years after pasture improvement has begun, there will be a negative cash flow (Wicksteed 1986). Not all farmers are in a position to carry this and credit facilities are not always available. There is also a certain risk involved that the improvement may fail, or that e.g. beef prices will decrease.

D.B. Coates (pers. comm.) listed as the main reasons for the present interest in pasture development based on legumes in Queensland (Gramshaw and Walker 1988) :

(a) better beef prices providing money for investment;

(b) changes in management brought about by compulsory herd testing for brucellosis and tuberculosis;

(c) high cost of mustering on very large properties;

(d) market pressures for higher quality beef and faster turnoff rate;

(e) more emphasis on business aspects of the grazing industry;

(f) simple technology of oversowing Stylosanthes into native pasture at relatively low cost;

(g) new approaches to extension;

(h) "successes" are increasing and so building up confidence.

4. The availability of resources and knowledge.

Before pasture improvement can be undertaken, there has to be an infrastructure for the distribution of the ingredients, e.g the seed and fertilisers. In many regions there is no seed production and no seed trade. Another very serious limitation for pasture improvement is the lack of finance and of knowledge by the farmers and the extension service.

It is therefore necessary to foster extension on pasture improvement, to encourage the development of seed production and trade and to educate bankers on the possibilities of pasture improvement.

Sustainability of pasture improvement

Sustainability of pastures has two aspects: ecology and economics. Ecological sustainability depends on the persistence of the sown forages and on the environmental effects of pasture use and management. The persistence of sown improved grasses (as listed in Table 1) depends mostly on soil fertility or fertiliser use and grazing pressure. Improved grasses require a source of nitrogen to be able to resist invasion and replacement by native grasses and weeds that are adapted to low fertility. Nitrogen can be supplied as fertiliser or by legumes. In the case of grass-legume associations, persistence of grasses therefore depends on the persistence of the legume. The environmental effects of grasslands in Central America mainly concern erosion and soil compaction. Erosion occurs when pastures are grazed on steep slopes as a result of cattle tracks. Steep slopes should not be used in agriculture, but reforested. Next to forest, well managed grasslands offer the best soil cover preventing erosion and building up soil organic matter. Soil compaction can be a problem in very wet areas. However, the effects of soil compaction are not well known and require further study.

Legume persistence is a function of the growth habit of the species, grazing pressure, palatability and soil fertility. Legumes can be divided into herbaceous and woody species. The herbaceous species can be further divided into three types of growth habit: trailing, erect and prostrate. Trailing legumes (e.g. Centrosema pubescens, C. macrocarpum, Macroptilium atropurpureum) are not tolerant of heavy grazing and will only persist under lenient grazing. Erect species (e.g. Stylosanthes spp.) are moderately tolerant of grazing pressure. Prostrate species (e.g. Arachis pintoi, Desmodium ovalifolium) are tolerant of heavy grazing. The main problem with trailing legumes is that their growing points are not protected against removal by defoliation. An important survival mechanism of herbaceous legumes is seed. Pasture grazing management should allow flowering and seed production of the species, so that a soil seed reserve can be build up. Intermittent grazing, or deferred grazing during flowering encourages seed production. With some prostrate legumes, e.g. Arachis pintoi, there is a danger of excessive dominance over certain grass species.

Grazing pressure is the most important management tool for animal production and pasture persistence. A high grazing pressure reduces selection possibilities for the animals and thereby their production and prevents legumes from flowering. Once the legume component of a pasture is reduced, grazing pressure on the remaining legume content increases and the danger of disappearance of the legume from the pasture becomes imminent. Grazing method (continuous, rotational) has a far lesser effect on legume persistence than grazing pressure, except for certain highly palatable species such as Leucaena leucocephala or Medicago sativa.

Palatability is important from the point of view of selection. Very high palatability can be detrimental to persistence of legumes. Most tropical legumes contain tannins, which reduce palatability. A certain level of unpalatability is favourable for persistence. Tannins also prevent the occurrence of bloat (tympanitis).

Low soil fertility can be a factor in legume persistence, particularly with regard to phosphate status and pH. Some legumes require more phosphate than others. E.g. Macroptilium atropurpureum has a greater phosphate requirement than Stylosanthes spp. In fact Stylosanthes spp. can grow and persist at very low phosphate levels. Generally tropical legumes have a good tolerance of low Ph, with the exception of Leucaena leucocephala and Neonotonia wightii.

Although there are no hard rules on the minimum of legume content in a mixed pasture, it is generally accepted that about 30 % legume on a dry weight basis is needed for an effective nitrogen supply to maintain productivity and the persistence of the sown grass.

The economic aspect of sustainability concerns the ability of a farmer to provide the proper management to the improved pasture in terms of fertilisers and stocking rate. When beef prices are very low for a considerable period, income is inadequate to purchase fertilisers and animal numbers are often kept high, resulting in excessive grazing pressure, because stock would have to be sold at a loss.

Conclusions

Low cost forage improvement technology based on legumes with minimal fertiliser input is available, which can improve animal production several fold. However, serious constraints are the lack of knowledge and resources, including finance.

Sustainable pasture improvement requires correct management which in turn requires training of farmers and adequate extension services.

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