Chapter 11

Alfalfa cultivars in Brazil

Maurício Marini Köpp
Antonio Vander Pereira
Reinaldo de Paula Ferreira

Introduction

The Brazilian cattle herd, estimated in over 205 million animals, is the largest one in the world, making Brazil the largest beef producer in the world and one of the biggest producers of milk from pasture-fed cattle (IBGE, 2009). Despite the gradual development of intensive production systems, both in pasture and in confinement, extensive production using cultivated pastures is predominant. This grants Brazil a highlighted position in the international market, which has been more and more demanding of beef and milk produced in more natural conditions and using less concentrates and chemicals (Zen et al., 2008). Brazil relies on over 220 million hectares of pasture, from which around 100 million are taken by cultivated forage and the rest is constituted of pasture formed by native and naturalized species (Jorge, 2008).

Brazilian soil and climate conditions allow cattle breeding to be developed all over its territory, with significant importance in the socioeconomic context of the country. Brazilian pastures are spread through different regions and different ecosystems (temperate climate, Cerrado, Semiarid, tropical wet, Pantanal) which have great environmental variability by themselves. Success in implementing pastures in such diverse environments implies the use of forages which have relatively distinct adaptation mechanisms that enable them to overcome the pressures from environmental stresses and to keep a high productivity.

Animal productivity achieved in tropical pastures is still low, when compared to the performance obtained in temperate climate regions where improved forage is used. The low productivity of tropical pastures during "winter" in central Brazil is one of the causes that contribute the most for the low productivity of the herds. This low pasture productivity is responsible for the reduction of the pasture's carrying capacity, for the marked decrease in milk production and for the weight loss of beef cattle, in that period. The inferior performance of tropical pastures can be related to three basic factors: using non-improved species and cultivars; using marginal or low fertility areas and inadequate pasture management (Pereira; Ferreira, 2008). Among these factors, replacing bad nutritional quality and low productive potential forage by improved cultivars constitutes an excellent alternative to obtain an increase in productivity.

Intensification of milk production in pastures constitutes an important goal of the dairy sector to make the activity competitive and economically profitable. This process has been occurring throughout Brazil, notably in the South, Southeast and Midwest regions. Due to market pressures, producers are looking for obtaining increased productivity per animal and per area, to keep the activity economically viable. For this purpose, it also becomes necessary to reduce the cost of animal feeding, considered the main component of expenses in milk production. In this sense alfalfa, as a forage with high dry matter production and high nutritional quality, can be an alternative feed by decreasing the amount of concentrate and corn silage, expensive components of the dairy activity, used in animal diet. Concentrate feeds represent roughly 60% of the feeding costs for milk cattle and 36% of the total costs. Corn silage represents about 17% of the feeding cost and about 10% of the total cost. Together, concentrate and silage represent about 77% of feeding costs for milk cattle and 47% of the total cost (Tupy et al., 2000). These results show the potential to insert alfalfa into sustainable and competitive systems of milk production in Brazil.

One of the barriers for the expansion of the alfalfa crop in Brazil is the low availability of cultivars adapted to tropical conditions. Currently, the only alfalfa cultivar with good adaptability and good stability in Brazil is the Crioula and there is great demand for new varieties in the market (Ferreira et al., 2004). The development of new alfalfa cultivars, with good adaptability and stability, will enable their cultivation in different regions of Brazil, with consequent increase of the area of exploitation and will thus ensure high quality and high productivity feeds for the intensive milk production systems (Pereira; Ferreira, 2008).

Another gap to solve is the production of seeds of enough quantity and quality (genetic and cultural) to meet the current and potential requirements of its growing market. The development and indication of cultivars adapted through genetic breeding programs is only justified if seeds are made available to the producer in the necessary amount, in due time and with satisfactory quality and fair price. Nowadays, the largest part of cultivated alfalfa in Brazil is from seeds imported from Argentina, Chile, and the United States of America, at the cost of R$ 30.00 per kilogram (Pereira; Ferreira, 2008).

The achievement of alfalfa cultivars adapted to the tropical climate can be addressed by genetic breeding programs through three basic methodologies: a) breeding of the Crioula population; b) introduction and evaluation of cultivars already bred in other countries; and c) achievement of synthetic populations based on recombining promising introduced genotypes. The process that can lead to the fastest results is introducing and evaluating the adaptation of cultivars bred in other countries. This methodology has been adopted by several institutions, aiming at the acceleration of the process of identifying adapted cultivars. At Embrapa Southeastern Livestock, national and introduced alfalfa cultivars were evaluated. In these evaluations, the materials LE N 4, P 30, Crioula, Barbara SP INTA and P 5730 stood out in dry matter production. LE N 4, P 30 and Crioula were the ones which had less disease infection (Rassini et al., 2007). LE N 4, developed by the company Palo Verde (Argentina) and introduced from the National Institute of Agricultural Technology (INTA, Argentina), has been presented as a relatively promising material, because it has reached dry matter production superior to Crioula. This promising cultivar is being subjected to the test of cultivation and usage value, with experiments being performed at Embrapa Southeastern Livestock (municipality of São Carlos, São Paulo state), at Embrapa Maize & Sorghum (municipality of Sete Lagoas, Minas Gerais state), at Embrapa Cerrados (district of Planaltina, Federal District), at Embrapa Soybean (municipalities of Londrina and Ponta Grossa, Paraná state), at Embrapa Temperate Agriculture (municipality of Pelotas, Rio Grande do Sul state) and at Embrapa Semi-Arid Region (municipality of Petrolina, Pernambuco state), aiming at a future recommendation as an alfalfa cultivar for Brazil, should its good adaptability and good stability be confirmed.

The future alfalfa cultivars will present increased yield and resistance to the several biotic factors. Also, it is desirable to develop cultivars with special characteristics enabling their use under specific environmental conditions and forms of use (cutting and pasture).

Alfalfa breeding for the cutting systems will select plants with high dry matter production, high forage quality, high capacity for fixating nitrogen, good tolerance to pests and diseases, small degree of winter rest and good persistency. For the pasture system, on the other hand, the necessity of incorporating tolerance to trampling and small bloat rate is added to these characteristics (Hijano; Basigalup, 1995).

The development of cultivars adapted to tropical conditions will result in a significant increase in the cultivated area of alfalfa, mainly to be used in intensive milk production systems of regions South, Southeast and Midwest, where the herds with greater nutritional requirements are located.

Alfalfa cultivation

Due to its potential in forage production and its adaptability to several environmental conditions, alfalfa is one of the most important forage species in the world, with over 32 million cultivated hectares (Costa; Monteiro, 1997). The USA, Russia, Canada and Argentina are the main producer countries. Alfalfa has excellent agricultural and qualitative characteristics, such as protein quality, palatability, digestibility, capacity of biological fixation of nitrogen into the soil and low seasonality of production; in addition, it has high contents of vitamins A, E and K, as well as the majority of minerals required by dairy and beef cattle, especially calcium, potassium, magnesium and phosphor (Ferragine, 2003).

Alfalfa can be supplied to animals in conserved form or in green ground form, or under pasture. The main forms to conserve alfalfa forage are hay (forage stored with moisture content under 20%), silage (forage stored with moisture content over 70%) and pre-dried (forage normally stored in polyethylene bags and with moisture content ranging between 40% and 60%). There are other less commonly used forms, such as pellets (forage dehydrated and compacted into high density cubes). Alfalfa can also be used under pasture and in green form offered in the through. In Argentina, alfalfa is used in large proportions for pasture and, in the USA, in hay form (Rodrigues et al., 2008). In Brazil, despite the most common use of alfalfa being as hay, several researches demonstrate the high potential of this forage when used for pasture (Costa; Saibro, 1994; Vilela, 1994, 2001; Saibro et al., 1998; Botrel et al., 2000; Oliveira, 2000; Oliveira et al., 2001; Ruggieri et al., 2001, 2005; Perez et al., 2002; Ferragine, 2003; Ferragine et al., 2004; Oliveira, 2006; Oliveira; Herling, 2006; Rodrigues et al., 2008).

It is estimated that the current area cultivated with alfalfa in Brazil is 30 thousand hectares, of which 90% is in Paraná and Rio Grande do Sul; this latter state is Brazil's biggest producer (Jorge, 2008). Alfalfa cultivation has been spreading to the Southeast and Midwest regions, in wider and more technified areas. The limiting factors for increasing alfalfa cultivation in Brazil are the lack of knowledge on cultivation techniques, low soil fertility, inadequate management, low availability of seeds and lack of cultivars adapted to tropical conditions (Paim, 1994; Ferreira; Pereira, 1999; Nabinger, 2002; Ferreira et al., 2004; Vasconcelos et al., 2008). In addition to these factors, the lack of knowledge about the control of invasive plants, of pests and of diseases, which occur more commonly in the tropics, significantly contributes for the low cultivation of this forage in Brazil.

Cultivars

Countries with a greater tradition in cultivating alfalfa, such as the USA, Canada and Argentina, have a large number of cultivars available, adapted to the different environments which they were selected for. Brazil, on the other hand, has most of its area cultivated with alfalfa taken from varieties of the Crioula population. The Crioula population results from a joint selection process, performed in Rio Grande do Sul state through introductions from

Uruguay and Argentina. The main varieties known from the Crioula population are: Crioula CRA, Crioula Itapuã, Crioula na Terra, Crioula Nativa, Crioula Ledur, Crioula Roque, Crioula Chile and Crioula UFRGS.

Alfalfa research results, both for cutting and for pasture, in tropical conditions and in subtropical conditions, have demonstrated superiority of the Crioula varieties, producing up to 25 t ha^{-1} $year^{-1}$ of dry matter, with low seasonality, high biological fixation of atmospheric N and efficient water use (Pereira et al., 1998; Oliveira, 2006; Oliveira; Herling, 2006; Rodrigues et al., 2008).

Introducing and evaluating cultivars already improved is an interesting strategy to adopt in breeding programs. Among cultivars introduced from other countries, only Monarca SP INTA, Super Leiteira, Trifecta, WL-325 HQ and WL-525 HQ are registered in the National Cultivar Registry of the Brazilian National Service for Cultivar Protection (Brasil, 2009) and can, therefore, have their seeds marketed in Brazil. However, it must be emphasized that the Crioula cultivar continues to be the most commonly planted in the country, with good adaptability and good stability.

Cultivar adaptability and stability

Phenotypic manifestation is the result of the action of the genotype under influence from the environment. However, when we consider a number of environments, besides the genetic effects and environmental effects, we detect the additional effect provided by the possible interaction between these effects. Evaluating the interaction of genotypes and environments is very important in breeding since, in case it exists, there is a possibility for the cultivar to show better behavior in a given environment – adaptability – and to repeat the performance in other environments – stability (Ferreira et al., 2000).

The causes of interaction have been credited to physiological and or biochemical factors inherent to each cultivated genotype. Since genotypes develop in dynamic systems, where constant changes take place, from sowing to ripeness, they usually have different behavior regarding the response to environmental variations (Cruz; Regazzi, 1994). Most economically important traits, such as production, are polygenic in nature and have their expression influenced by environmental conditions and by the effects of the interaction between genotypes and environments (Allard, 1971).

It has been frequent in breeding programs to evaluate the behavior regarding a group of cultivars faced with environmental variations, considering different locations as environments. However, studies on the interaction between cultivars and environments do not provide detailed information of the behavior of each cultivar facing the environmental variations. For this purpose, it is necessary to perform adaptability and stability analyses, through which it becomes possible to identify cultivars with predictable behavior and that respond favorably to environmental variations in specific conditions or in broad conditions (Cruz; Regazzi, 1994).

Because of these aspects, the interaction between genotypes and environments is an extremely important factor to consider in plant breeding. For the producers, it is interesting for plants to show maximum expression of their genetic potential, in the form of economically applicable products, such as grains, forage and fruits. For that purpose, environmental conditioning or the use of specific cultivars for each environment becomes necessary, so that the maximum potential is extracted from the cultivars (Pereira et al., 2001). Since standardizing cultivation environments is practically impossible due to the costs involved, the possible solution to keep high crop productivity in diverse environments is to use plants genetically adapted to each location.

The strategy of selecting plants adapted to the specific conditions of cultivation environments has been adopted in breeding programs of important species, such as maize, rice, wheat, bean, soybean and cotton. It is based on this work that it has been possible for breeding programs to release superior cultivars adapted to different soil and climate conditions.

In alfalfa and in other perennial forage species, morphological, physiological and agricultural traits which promote yield, forage quality and plant persistency in production systems are usually sought. The dry matter yield potential of cultivated alfalfa is estimated in up to 25 t ha^{-1} $year^{-1}$; however, in most cases this potential is not reached, due to environmental limitations, considered in broad form (Ferreira; Pereira, 1999).

In tropical regions, the rain system is an important factor interfering in the adaptation of alfalfa, due to its influence on soil moisture and pH (Melton et al., 1988). Alfalfa adapts better to deep, well drained, slightly alkaline soils with high fertility. Soil acidity is usually related to high precipitations, and alkalinity, to low precipitations. Susceptibility to pests and diseases is the main limitation for alfalfa to adapt to a given environment (Paim, 1994; Hijano; Basigalup, 1995). Disease and pest incidence is influenced by intensity of rain and by temperature (Melton et al., 1988) and can occur in leaves, stems, roots and seeds and is usually more frequent under high temperature and humidity conditions, typical of tropical regions. Damages caused by pests and diseases, mainly to leaves, cause an increase in the stem:leaf ratio, with a negative reflex on forage quality because of the increase in fiber content and the decrease in crude protein content. Susceptibility to pests and diseases can, in many cases, be the main reason of the low persistence of this legume (Bueno; Silva, 2008; Porto, 2008).

Despite the good performance that an alfalfa variety may have regarding dry matter production, it is necessary for it to also demonstrate response to environmental improvement and predictability of behavior. However, because of the effect of the interaction between genotype and environment, many times a variety that is superior in certain environmental conditions may not keep this superiority in another environment. Thus, the detailed study of the behavior of a genotype, when faced with environmental variations, has been very important, for allowing the most efficient recommendation and use of the genetic material available (Cruz; Regazzi, 1994).

Due to differences in adaptation between cultivars (interactions between genotypes and environments), to environmental requirements and to the current stage of alfalfa breeding programs aiming at obtaining “tropical cultivars”, the adoption of strategies that enable more speed for evaluating and selecting genotypes becomes necessary. One of the solutions breeders have found to address the need of quickly evaluating materials in diverse environments is the performance of online assays, through a standardized methodology. The work is normally developed in a partnership among researchers from several institutions, which enables the performance of experiments in several environments simultaneously, as well as comparing the results obtained among locations.

In the case of alfalfa, the National Network for the Evaluation of Alfalfa Cultivars (Renacal) [*Rede Nacional de Avaliação de Cultivares de Alfafa*] was organized, with the objective of recommending alfalfa cultivars for different regions in Brazil.

National Network for the Evaluation of Alfalfa Cultivars

In 1994, Embrapa Dairy Cattle, attentive to the growing interest in the alfalfa crop, promoted a meeting among national and foreign researchers, extension professionals, technicians and producers, with the objective of evaluating the potentialities and limitations of alfalfa for milk production in tropical regions. Among the conclusions of the meeting, carrying out researches aiming at adapting alfalfa cultivars to different tropical environments was highlighted as prioritary (Botrel; Alvim, 1994). At this meeting, it was proposed to create a network of experiments to evaluate the adaptation of national varieties and introduced varieties to the different regions of Brazil. Thus, the National Network for the Evaluation of Alfalfa Cultivars was created with the objective of identifying and recommending cultivars for such regions. The network was designed based on the use of a standardized experimental methodology, allowing performing comparisons between results from experiments carried out in different locations (Botrel; Alvim, 1994).

The Network was conducted from 1995 to 2005, with experiments performed in over twenty locations of the Southeast, Midwest, South and Northeast Brazilian regions. The following research and teaching institutions were part of the Network: Embrapa Dairy Cattle; Embrapa Southeastern Livestock; Foundation College of Agronomy Luiz Meneghel [Fundação da Faculdade de Agronomia Luiz Meneghel], municipality of Bandeirantes, Paraná state; São Paulo Agency of Agribusiness Technology, Sertãozinho Experimental Station [Agência Paulista de Tecnologia do Agronegócio – Estação Experimental de Sertãozinho]; Federal University of Lavras [Universidade Federal de Lavras]; Vale do Rio Doce University [Universidade do Vale do Rio Doce]; Rio Verde Educational Foundation [Fundação de Ensino de Rio Verde], municipality of Rio Verde, Goiás state; Agency for Rural Development of Goiás State [Agência Goiana de Desenvolvimento Rural e Fundiária]; Bahia State Agricultural Development Corporation [Empresa Baiana de Desenvolvimento Agrícola]; Agricultural Research Corporation of Rio de Janeiro State [Empresa de Pesquisa Agropecuária do Rio de Janeiro]; State Agricultural Research Corporation of Minas Gerais [Empresa de Pesquisa Agropecuária de Minas Gerais]; Espírito Santo Research Institute [Instituto Capixaba de Pesquisa], Technical Assistance and Rural Extension [Assistência Técnica e Extensão Rural]; Agronomic Institute of Paraná [Instituto Agronômico do Paraná]; Agricultural Research and Rural Extension Enterprise of Santa Catarina [Empresa de Pesquisa Agropecuária e Extensão Rural de Santa Catarina]; Federal University of Rio Grande do Sul [Universidade Federal do Rio Grande do Sul]; Federal Rural University of Pernambuco [Universidade Federal Rural de Pernambuco]; Federal University of Paraiba [Universidade Federal da Paraíba]; and Federal University of Ceará [Universidade Federal do Ceará].

At each location, the experimental design used in Renacal was the casualized blocks, with four repetitions for three years. The plots were constituted of 5 m long rows with 15 cm spaces (plot area: 10 m x 5.0 m x 0.15 m = 7.5 m^2). Two rows at each side and 0.5 m off each extremity of the plot were considered as borders. Treatments were constituted of 20 alfalfa cultivars. The following characteristics were evaluated: stem, crude protein rate in leaves, stems and in the whole plant, persistence and tolerance to pests and diseases.

In Renacal, in several experiments and under cutting conditions, around 50 alfalfa cultivars were tested, and their adaptation to climate and soil conditions from various regions of Brazil were evaluated. Results revealed that alfalfa shows good behavior in various environments, with differential response among the tested cultivars. Crioula and P-30 stood out in most environments, indicating that they show a broad band of adaptation and are therefore recommended for cultivation in areas under influence of Atlantic forest, Cerrado and subtropical climate ecosystems.

Evaluation of cultivars

The number of cultivars available for cultivation is directly related to the adoption and the cultivation of alfalfa in each country. The United States of America, Canada, Argentina and Italy have a relatively large number of improved cultivars available, because they have relatively large areas of alfalfa production. Investment on breeding programs for this forage in these countries clearly reflects their respective productivity in the alfalfa crop. In these countries, breeders have developed cultivars with high productive potential and with great resistance to the main causes of biotic and abiotic stress. Another determining factor of investments in breeding this forage is related to the market of seed commerce, which has great representativity in these countries (Wilkinson; Castelli, 2000; Nabinger, 2002).

The alfalfa crop in Brazil is concentrated in the South region, where Rio Grande do Sul state represents around 80% of the planted area. This situation may be related to cultural aspects of the first producers (immigrants), who already knew this forage, and to the occurrence in the region of similar soil and climate conditions to those prevailing in the traditional producer countries. Researchers from this region were also pioneers in Brazil in the goal of identifying adapted cultivars (Bassols et al., 1979; Zimmer et al., 1982; Fischer et al., 1984; Saibro, 1985; Saibro et al., 2001), in addition to studying the establishment and management of alfalfa under the soil and climate conditions of the South of Brazil.

The growing interest for the productive potential of alfalfa in tropical climate regions is due, mainly, to the intensification of milk and beef production systems (Costa; Saibro, 1994; Vilela, 1994; Oliveira, 2000, 2006; Perez et al., 2002; Ferragine, 2003; Perez, 2003; Ferragine et al., 2004; Ruggieri et al., 2005; Oliveira; Herling, 2006; Pereira; Ferreira, 2008). Researches with alfalfa in tropical conditions have been showing that, in addition to high potential for production and high nutritional value, this legume has variability for adaptation to soil and climate conditions of different regions (Botrel et al., 1992, 2000, 2001, 2005; Evangelista et al., 1993, 2000; Botrel; Alvin, 1997; Viana et al., 1998; Ferreira et al., 1999, 2004; Vieira et al., 2000; Uchoa et al., 2000; Ruggieri et al., 2001; Lédo et al., 2004, 2005; Costa et al., 2006; Heinemann et al., 2006; Rassini et al., 2007; Vasconcelos et al., 2008). Identifying cultivars adapted to tropical conditions is a prioritary goal which aims at using this legume as high quality and high productivity feed in intensive production systems.

Alfalfa cultivars were evaluated for their adaptation to different ecosystems (Cerrados, Atlantic forest, temperate climate, semiarid) by Renacal. Next, alfalfa cultivars indicated for the cutting and the pasture system were detailed.

Cultivars for cutting

In the works performed by Renacal, 50 alfalfa cultivars introduced from other countries, especially from Argentina and from the USA, were evaluated, in addition to cultivars developed from the Crioula population grown initially in Rio Grande do Sul state. The results obtained from the assays of Renacal showed that alfalfa is an excellent forage resource, standing out for its productivity and for forage quality.

The results of the evaluations by Renacal generally showed a major difference in dry matter production according to the location where the cultivars were tested. However, in all environments, cultivars with high productivity were identified (Table 1). The productivity of the best cultivars matches the indices observed in other countries which are traditional producers of this forage. These results indicate the existence of high influence by the genotype and the environment in the evaluated cultivars. The regions where the best productivity was achieved were the municipalities of Bandeirantes (Paraná), Sete Lagoas (Minas Gerais) and Manoel Vitorino (Bahia) and the worst, in Eldorado do Sul (Rio Grande do Sul), Rio Verde (Goiás) and Governador Valadares (Minas Gerais). It is worth reiterating that the productivity achieved reflects the interaction of several factors involved in the productive system and, thus, the occurrence of adverse factors not controlled by the researchers may have contributed for the low productivity in some locations. Another fact is that these results are not representative of historical series of productivity of the cultivars. Therefore, they only provide a preliminary idea of the behavior of the cultivars in each location.

It was the Crioula cultivar that had the best productivity index, which means ranging from 9.0 t ha^{-1} $year^{-1}$ to 21.3 t ha^{-1} $year^{-1}$. This was the most productive cultivar in seven locations. The P-30 cultivar also achieved excellent annual production of dry matter, ranging from 7.9 t ha^{-1} to 22.9 t ha^{-1}. These cultivars had a broad band of adaptation to the various tropical environments in which they were evaluated, confirming the good performance in Brazilian soil and climate conditions. Possibly because of the lack of improved cultivars adapted to tropical

Table 1. Annual forage dry matter (DM) production, achieved by the three most productive alfalfa cultivars, in 14 locations.

Location (municipality and state)	Cultivar	Annual forage dry matter (t ha^{-1})
Coronel Pacheco, MG	Crioula	13.0
	Monarca	11.9
	P-30	11.8
Sete Lagoas, MG	Crioula	20.0
	P-30	19.6
	Rio	16.8
Lavras, MG	Crioula	17.5
	P-30	16.3
	P-5715	13.7
Governador Valadares, MG	Crioula	10.3
	Victoria	10.3
	CY-9313	9.6
Paty do Alferes, RJ	Crioula	14.2
	P-30	14.0
	Maricopa	13.8
Sertãozinho, SP	SW-8210	14.0
	Monarca	13.9
	P-5715	13.7
São Carlos, SP	Crioula	16.4
	P-30	13.3
	WL-516	12.5
Rio Verde, GO	Crioula 1	9.8
	Crioula 2	9.0
	P-30	7.9
Eldorado do Sul, RS	Crioula	9.2
	Rio	8.9
	P-30	8.4

Continued...

Table 1. Continued.

Location (municipality and state)	Cultivar	Annual forage dry matter (t ha^{-1})
Bandeirantes, PR	P-30	22.9
	WL-516	22.8
	Crioula	21.3
Chapecó, SC	Alto	13.9
	BR-3	13.4
	SW-8112	13.0
Areia, PB	XA-132	17.1
	Crioula	15.3
	SW-14	14.4
Pentecoste, CE	SW-9301	15.2
	P-30	14.4
	Victoria	14.4
Manoel Vitorino, BA	Cordobesa	18.9
	P54H55	17.9
	Victoria	17.1

Source: Botrel (2005).

conditions, it is observed that the Crioula cultivar or populations deriving from it are always among the most productive ones, although some introduced cultivars are superior in some environments. Another highlight is the Victoria cultivar, which despite not having the highest production in any location, was distinguished by being one of the three most productive cultivars in two lower latitude states (Ceará and Bahia), where the characteristic climate is tropical semiarid.

Cultivars for pasture

There are few studies on milk production of cattle in alfalfa pastures, especially in tropical climate. Vilela (1994) presented the results of evaluating two management systems for cattle with high potential for milk production: one of them had an alfalfa pasture as the only feed and the other, corn silage and concentrate, in which the animals were kept in total confinement; it was concluded that using alfalfa pasture as exclusive food for lactating cows was viable, since it had the potential to support three cows per hectare and to provide an average daily milk production of 20.0 kg per cow, achieving 23.6 kg per cow in the beginning of lactation, without compromising the live weight and the reproductive efficiency of the animals. Works carried out at Embrapa Southeast Livestock (Netto et al., 2008a, 2008b) showed that using alfalfa in pasture, as part of the diet of cows fed with corn silage and 5.0 kg of concentrate, at the middle stage of lactation, enabled an average daily production of 25 L of milk per cow. This represents a significant saving in the amount of concentrate generally used daily (8 kg) to achieve this level of production, as well as the possibility of reducing the protein content of the concentrate and the amount of corn silage needed, which contributes for reducing the production cost of milk. Based on this work, Vinholis et al. (2008) observed a reduction in the production cost of milk of 9% and of 15%, when alfalfa participated with 20% or with 40% of the dry matter in the diet, respectively.

In terms of breeding, the content of non-structural carbohydrates accumulated in the roots may indicate persistence and tolerance to grazing (Smith et al., 1989). Tolerance to grazing can also be related to the residual leaf area and to strength of resprouting. Plants which have decumbent stems with tissue accumulation next to soil level can store a larger amount of photoassimilate, increasing resprouting capability and, consequently, tolerance to grazing. Prostrated stems, number of stems, number of crowns, crown area, forage yield, residual leaf area, root weight after defoliation and non-structural carbohydrates concentration are currently the most commonly used variables to evaluate alfalfa cultivars under pasture (Brummer; Bouton, 1991, 1992).

When Perez et al. (2002) evaluated cultivars ABT 805, Crioula Chilena, Crioula Roque and Crioula Ledur in Southern Brazil, they found survival of 90%, 65%, 59% and 55%, respectively. In a study in pasture conditions (continuous and rotational grazing), Ferragine (2003) observed that under continuous grazing, there was death of cultivars Crioula Chilena and CUF 101 and low survival of the other cultivars. Under rotational grazing, production was lesser, but with survival of 44.9%; 34.4%; 28.2%; 27.6% and 24.9% of cultivars ABT-805, Alfagraze, CUF 101, Crioula Chilena and Pioneer 5432, respectively. Despite the low survival in continuous grazing, the Crioula cultivar achieved the best performance in rotational grazing conditions, with annual production of 18.3 $t.ha^{-1}$ of dry matter. Ruggieri et al. (2005) also demonstrated that the Crioula cultivar was the one with the best productivity and the most recommended for pasture, in a study carried out in the municipality of Sertãozinho, São Paulo state, after eight grazing cycles intercalated with resting periods.

Oliveira et al. (2001) tested twelve alfalfa cultivars in pasture conditions for four short term grazing cycles. In this study, cultivars Crioula Chilena and Pioneer 5312 were the ones with better survival (39.9%) and greater keeping of the crown. Productivity (t ha^{-1} of dry matter per cycle) was 2.60 for Crioula Chilena, 1.74 for Pioneer 5312 and 1.74 for Pioneer XAI 32, in rotational grazing. These results indicate that the Crioula cultivar was the most productive in rotational grazing conditions, with high stocking. Oliveira (2006), evaluating 19 alfalfa cultivars in the municipality of São Carlos, São Paulo state, in pasture conditions over 11 months, determined that cultivars Crioula RS, Crioula Chilena and Crioula Itapuã were the ones that stood out the most, with productivity between 20 ha^{-1} year^{-1} and 22 t ha^{-1} year^{-1} of dry matter, quite favorable production seasonality between 35% and 40%, and survival between 80% and 100% (Table 2). When assessing the same 19 cultivars in the municipality of Pirassununga, São Paulo, and in five grazing cycles, Oliveira and Herling (2006) verified that the most productive cultivars in dry matter were Crioula RS with 15.2 t ha^{-1} year^{-1}, Amerigraze with 13.9 t ha^{-1} year^{-1} and Crioula Itapuã with 14.0 t ha^{-1}. Regarding the survival rate, there was no variation among the cultivars evaluated, and the mean was 73.5% (Table 2).

Table 2. Annual production of forage dry matter (DM), achieved by the nine most productive alfalfa cultivars in pasture, in two tropical climate municipalities.

Cultivar	São Carlos, São Paulo(1)		Pirassununga, São Paulo(2)	
	DM (t ha^{-1})	Seasonality (%)	DM (t ha^{-1})	Survival (%)
Amerigraze	16.6	34.8	13.9	78.8
Crioula Chilena	21.1	44.0	11.5	57.6
Crioula Itapuã	21.5	39.2	14.0	69.8
Crioula RS	21.8	43.3	15.2	106.6
CUF 101	18.8	36.2	12.0	56.1
Pioneer 5454	18.2	32.0	11.0	55.8
SW 8200	18.0	38.8	13.0	68.6
ZG 9786	18.3	40.3	13.9	80.0
ZG 9797	18.3	38.7	12.0	68.3

(1) Annual average of two seasons: rain season of 2004–2005 and dry season of 2005.

(2) Twelve months production.

Source: Oliveira (2006) and Oliveira and Herling (2006).

Crioula alfalfa

The Crioula population results from a joint selection process carried out by man and nature, in Rio Grande do Sul state, from the introduction and cultivation of alfalfa in the valleys of rivers Caí, Taquari, Jacuí and Uruguay and in the border of the Mountain Range, which started around 1850 (Saibro, 1985; Oliveira et al., 1993; Perez, 2003). In these crops, producers harvested seeds from four to five-year-old alfalfa plantations, which ended up generating the Crioula population. The consequence to this selection process was the development of a population with broad genetic variability and good adaptation to most environments.

Crioula alfalfa is characterized by not presenting leaf drop during its development, which results in greater accumulation of reserves in the roots and crown of the plant. This leaf retention allows intense and strong resprouting and leads to fast recovery of leaf area after the cuts, with good dry matter yield, good seasonal distribution and great persistence. In addition, because it is a cultivar without winter rest, it shows active growth during autumn and winter (Saibro, 1985; Honda; Honda, 1990; Nuernberg et al., 1990). The Crioula population has an upright growth habit, an interesting characteristic for haymaking, to which purpose it has been cultivated the most in Brazil (Perez, 2003), as well as variation of persistent plant types, ideal for pasture (Favero, 2006).

In Brazil, almost the entire area cultivated with alfalfa is taken by the Crioula cultivar or by populations derived from it (Crioula CRA, Crioula Itapuã, Crioula na Terra, Crioula Nativa, Crioula Ledur, Crioula Roque, Crioula Chile, Crioula UFRGS and others).

Results from experiments conducted in several locations have demonstrated that the Crioula cultivar, or populations derived from it, is always among the best performing ones in forage production (Ferreira et al., 1999, 2004; Botrel et al., 2000, 2001, 2005; Oliveira, 2000; Oliveira et al., 2001, 2003, 2004; Lédo et al., 2004, 2005; Heinemann et al., 2006). Pereira et al. (1998) evaluated the performance of seven Crioula cultivars (Crioula CNPGL, 5715, Rio, Crioula original, Flórida 77, Vale Plus and Crioula EEA-UFRGS) for some characteristics of forage importance, such as dry matter production, plant height, percentage of blooming flowers at cutting time and disease incidence. The authors observed that materials originated from the Crioula cultivar displayed superiority for most of the traits evaluated. These studies revealed that Crioula alfalfa has potential of yearly dry matter production of up to 25 $t.ha^{-1}$, with low seasonality, high biological fixation of atmospheric N and good efficiency of water use.

Breeding of Crioula alfalfa

Through an experiment of polycross progenies test, Oliveira et al. (1993) proved that Crioula alfalfa has genetic variability in dry matter yield, plant height, leaf:stem ratio and crude protein content. Due to this genetic variability, Crioula alfalfa has been used as genetic material to obtain derived cultivars. Breeding programs for this population have been carried out by Embrapa Dairy Cattle, by Embrapa Southeast Livestock and by the Federal University of Rio Grande do Sul (Ferreira; Pereira, 1999; Dall'agnol et al., 2007; Rassini et al., 2007).

Embrapa Dairy Cattle started its alfalfa breeding program in 1996, with the goal of obtaining cultivars that were indicated for production in tropical climate and which had certain characteristics, such as combined resistance to the main pests (*Acyrthosiphon pisum* (Harris) [pea aphid], *Acyrthosiphon kondoi* Shinji [blue alfalfa aphid] and *Aphis craccivora* [alfalfa black aphid]) and diseases (*Colletotrichum trifolii* Bain & Essary [anthracnose] and *Leptotrochila medicaginis* (Fckl.) Schüepp [yellow leaf blotch]), persistency, smaller degree of winter rest and high potential for seed and forage production.

To develop a population more adapted to the tropical environment, selection was performed in a population of Crioula alfalfa, in which plants were selected based on characteristics of forage interest. The resulting population was experimentally called "Crioula CNPGL". This material was evaluated in experiments with other populations derived from the original Crioula, aiming at estimating gains from selection and adaptation to tropical conditions (Pereira et al., 1998). When traits of production and percentage of dry matter, disease tolerance and plant height were evaluated in seven cuts, the cultivars Crioula (original), Crioula CNPGL and Crioula EEA-UFRGS showed remarkable behavior in relation to the other genotypes (Table 3). Results showed that the Crioula cultivar has a high percentage of dry matter, better tolerance to disease and higher plants in relation to the other introduced cultivars. The selection process did not change these traits in the derived populations (Crioula CNPGL and Crioula EEA-UFRGS). In dry matter production per area, populations Crioula (original) and Crioula CNPGL stood out from the rest, which indicates that they are better adapted to tropical conditions.

The Crioula CNPGL population is being subjected to the test of cultivation and usage value, aiming at its release as a cultivar for cutting, adapted to tropical conditions. Other studies on alfalfa breeding were carried out with the goal of selecting materials with high seed production, high dry matter production and high persistence (Bassols et al., 1979; Oliveira, 1991; Oliveira et al., 1993; Fão, 1995; Dutra, 1999).

Table 3. Averages of dry matter (DM) percentage, height of the plant (HP), blooming (BLO), disease incidence (DIS) and dry matter production (DMP) in alfalfa cultivars, in seven successive cuts.

Varieties	Characteristics				
	DM (%)	HP (cm)	BLO (%)	DIS[(1)]	DMP (kg ha^{-1})
Crioula CNPGL	25.0	47.7	5.2	2.04	1,131
Cultivar 5715	24.4	37.7	2.3	3.61	830
Cultivar Rio	23.3	39.9	2.8	2.85	833
Crioula (original)	25.1	45.4	6.1	2.62	1,012
Flórida 77	23.7	42.1	3.7	4.57	865
Vale Plus	23.4	37.6	2.2	3.38	758
Crioula EEA-UFRGS	25.9	46.0	10.0	2.38	819

(1) Based on scoring, where 1 = resistant and 5 = susceptible.
Source: Pereira and Ferreira (2008).

When Favero (2006) compared alfalfa populations with different capabilities, she observed similarity between Crioula alfalfa and the Alfagraze cultivar (reference as a cultivar for pasture) in allocation of carbohydrates for the root system. This characteristic is associated with plant resistance in pasture and demonstrates that Crioula alfalfa displays variability for breeding aiming at pasture. These results show that Crioula alfalfa, in addition to performing better for cutting, also stands out in pasture. The genetic variability found in Crioula alfalfa allows selecting materials for these two goals.

Final considerations

Some countries, as the USA, Canada and Argentina, have several cultivars adapted to their different available environments. In Brazil, however, most of the area is cultivated with varieties originated from the Crioula population, which has the best productivity indices comparatively to the other cultivars. This population originated from a selection process carried out in Southern Brazil, from introductions performed from Uruguay and Argentina which brought about several varieties usually called Crioula + “variety selection location”. In addition to these varieties, the following cultivars are registered in the National Cultivar Registry [Serviço Nacional de Proteção de Cultivares]: Monarca

SP INTA, Super Leiteira, Trifecta, WL-325 HQ and WL-525 HQ. There are also several other cultivars without official registration which spread nationwide with the most diverse names and which were introduced mainly from Argentina and from the USA.

Regarding the recommendation of cultivars for pasture, there are still no recommended cultivars of national origin. Some studies evaluated the potential of cultivars for pasture, in which the Crioula variety presented good results. Some cultivars, such as ABT-805, Maxigraze and Amerigraze, of foreign origin, are reported in the literature as being tolerant to pasture but did not show good adaptability and good stability in Brazil.

New alfalfa cultivars must be developed, with adaptability and stability to tropical conditions, increased yield and resistance to the diverse abiotic and biotic factors, in addition to characteristics which enable their use in specific conditions of environment and using forms (cutting and pasture).

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