SUMMER FORAGE FEEDING ALTERNATIVES: OPPORTUNITIES AND CHALLENGES FOR PASTORAL SYSTEMS IN URUGUAY

Walter Ayala[1], Fabio Montossi, Ethel Barrios, Raúl Bermúdez, Robin Cuadro, Santiago Luzardo, Carolina Silveira, Enrique Pérez Gomar, Virginia Pravia, Pablo Rovira, and José Velazco.

National Institute of Agricultural Research (INIA), Treinta y Tres, Uruguay.
wayala@tyt.inia.org.uy[1]

KEYWORDS: forage species, summer feeding, extensive systems

INTRODUCTION

During many years, pasture production research in Uruguay has been focused on the development of winter strategies to increase forage supply and quality, looking for positive influences on animal production. However, the variation in pasture production level and persistence has been substantially increased, especially in farms with important proportions of improved pastures, as a consequence of unpredictable changes in summer climate. This implies changes in management practices at the farm level, resulted in new needs of additional information for farmers provoking the refocus of the research on this subject to cope with the new technology demands. Moreover, regional future climate change predictions are about increase temperature, rainfall regimes variability and higher frequency of extreme climate phenomenon (Travasso, 2008). Potential management options vary from the use of alternative forage species for particular purposes during summer, including fattening and rising processes both in beef and sheep. In Uruguay, summer feeding alternatives which could contribute to improve and stabilize animal production levels are limited. There have been some interesting experiences in some regions of Uruguay using alternative forage species for strategic purposes in improvement animal performance in comparison with traditional production systems. Different summer forage alternatives were used, including annual and perennial species, from those droughts tolerant to high performance species under irrigation as well as those from high production with low quality to high production and high quality forage species. This paper discusses the results of the use of alternative species for

increasing animal potential production during summer, under contrasting and limiting environments. A series of trial results performed in the last five years by the *National Programs of Pastures & Forages* and *Meat & Wool of INIA Uruguay* is discussed in this paper, describing the results obtained using different species (summer legumes, forage brassicas, plantain, setaria or sorghum) for feeding sheep and beef under different production systems of Uruguay.

Summer forage alternatives

a) Legumes

Lotus corniculatus (lotus), is a forage legume adapted to wide range of environments, particularly acid and low fertile soils and tolerant to drought conditions. It is a species recognized by its productivity and nutritive value during summer. Intensive and frequent grazing affects productivity and persistence of lotus (Ayala, 2001). A trial was conducted in INIA Treinta y Tres to evaluate lotus cv. INIA Draco as a summer feeding alternative for fattening Texel lambs, evaluating carrying capacity and lamb performance from late December to early April (98 days). A rotational grazing system was used, with three paddocks allowed with grazing and resting periods of 10 and 20 days, respectively

Herbage mass was high over all the period (Table 1), declining with the increase of stocking rate mainly in the second and third grazing periods (Ayala et al., 2007). Leaf/stem ratio was not affected by treatments, however green/dry forage ratio declines with the stocking rate increase from 10 to 20 or more lambs/ha. Lamb performance was similar between 10 to 20 an/ha, being reduced on average by 50%, when stocking rate was increased by 30 an/ha. Maximum levels of liveweight (LW) production and individual carcass weight (100% of carcasses above of 17 kg) were achieved with 20 an/ha (Ayala et al., 2007).

Table 1. *Herbage mass, leaf/stem ratio and green/dry forage ratio for the average and animal performance on a lotus sward grazed by Texel lambs from late December to April (Adapted from Ayala et al., 2007).*

Variables	Stocking rate (lambs/ha)		
	10	20	30
Herbage mass offered (DM t/ha)	3.4 a	3.1 a	2.7 b
Leaf /stem lotus ratio	0.5	0.7	0.6
Green/dry forage ratio	3. 7 a	2.1 b	1.7 b
Liveweight gains (kg/an/day)	0.152 a	0.135 a	0.071 b
Liveweight production (kg/ha)	147 c	263 a	206 b

Different letters in rows show differences between treatments (LSD; P<0.05).

Trifolium pratense (red clover), like lotus is one of the legumes with high production during summer. During 62 days, a red clover cv. INIA Mizar sward was evaluated at "Palo a Pique" Experimental Unit of INIA Treinta y Tres for lamb fattening, from late December to February. The sward was evaluated using 17 Corriedale lambs/ha, which had an average initial weight of 21 kg. At the end of December the herbage mass was 4.1 t DM/ha with 18 cm sward height. Individual liveweight gains achieved were 0.094 kg/an/day for the period, producing 99 kg/ha of liveweight. In general, red clover tends to increase herbage production during February, but simultaneously the reproductive process affects forage quality and in consequence animal performance declines. Therefore, red clover appears as a forage alternative of high quality early in the season compared with lotus.

There are other experimental reports comparing lotus and red clover performance, for finishing lambs during summer, included the shade effect on animal productivity. The performance of Corriedale lambs (23.3 kg LW) was evaluated comparing the effects of artificial shade from November to February (98 days), using either Lotus cv. INIA Draco and red clover cv. INIA Mizar swards (Table 2). A significant effect of shade was detected on lotus but not on red clover pasture; however a trend ($P<0.10$) was also observed in favor of shade on red clover sward. Considering climatic change predictions, more significant effects of shade protection could be expected in the future, adding the beneficial effect on animal welfare.

Table 2. *Effect of artificial shade over the performance of Corriedale lambs grazing either lotus or red clover during summer (Ayala et al., unpublished data).*

	Lotus cv. INIA Draco		Red clover cv. INIA Mizar	
	Without shade	With shade	Without shade	With shade
Herbage mass offered (DM t/ha)	3.0	3.0	2.5	2.5
Stocking rate (lambs/ha)	13	13	9	9
Liveweight gains (kg/an/day)	0.144	0.167	0.129	0.162
Liveweight production (kg/ha)	183	213	114	142
Sig. of Shade effect on liveweight gains	*		ns	

** (P<0.05; ns, not significant).*

The use of irrigation as an alternative to increase herbage production was evaluated during summer in the Basaltic region of Uruguay. In this way, was performed an experiment in the summer 2009 at "Glencoe" Experimental Unit, INIA Tacuarembó.

The pasture used was a red clover cv Estanzuela 116 dominant pasture managed under irrigation and grazed by Corriedale and Corriedale*Merino Donhe lambs (24.5 kg initial LW) at 20 an/ha with or without maize supplementation (at 1% of LW). On average after 127 days of experiment, the pre and post herbage mass were 2.5 and 1.8 t DM/ha. Partial animal information from February to April /79 days) showed in fasted liveweight gains of 0.151 and 0.158 kg/an/day for unsupplemented and supplemented treatments, which resulted in production of 230 and 250 kg LW/ha, respectively (Montossi et al., pers. comm.). When the whole period (February to June; 127 days) was considered the differences became significant ($P<0.01$) and resulted in 0.112 and 0.147 kg/an/day and 284 and 373 kg LW/ha, respectively. These results were obtained in a period of a severe drought, showing the importance of this kind of alternatives in terms of increasing and stabilizing production in extensive systems under climatic challenges.

b) Forage Brassicas

Forage brassicas have high nutritional value for ruminants (Garret et al., 2000), with high digestibility (>85%), high energy (2.75-3.22 MCal/kg DM), low fiber content (<18%) and medium to high levels of crude protein (12-20%). Brassicas are widely used in New Zealand and recommended as an alternative when quantity and quality of forage supplied is limiting animal performance, particularly for finishing processes during summer as well as initial crop previous pasture renewal (P. Kemp, pers. comm.). There is a set of recommendations to avoid some risks when animals fed brassicas, mainly the fiber addition into the diet to correct metabolic disorders (Reid et al., 1994).

New Zealand results reported liveweight gains between 0.250-0.300 kg/an/day in lambs grazing brassicas (Nichol and Garret, 2001). Productive systems of Uruguay demand summer forages with high quality responding to specialized animal productive processes, like finishing lambs. However, there is no tradition and experience in the use of brassicas in our productive conditions. In 2005, an INIA Uruguay´s project started to evaluate the adaptation of different species (turnips, forage rape or forage brassicas), dates and sowing methods, evaluating its potential in being utilized mainly for finishing lambs during summer.

The performance of brassica species in the medium rolling prairies in eastern region of Uruguay is highly dependent of climatic conditions, being negatively correlated

with the rainfall regimes. Forage production during the whole season for November sowing dates achieved a range between 5.8-8.6 t DM/ha, reaching 3 to 3.5 t DM/ha at the first grazing of 50-60 days after sowing (Ayala et al., 2007, 2008, 2009). In this region, recommended sowing date varies from October to November. In terms to extend the grazing season, autumn sowing dates were tested, but materials in early spring started to flowering and lost quality. Lambs performance was tested at different stages (vegetative, early mature and late mature; Table 3) of the crop using the cv Pasja with different stocking rates. At vegetative stage, lambs performance at 24 an/ha was the lowest compared to the others stocking rates as a consequence of presence of *Solanum nigrum* in the field, which is a toxic weed preferred by lambs. At high stocking rates, lambs grazed partially bulbs, increasing the incidence of the diseases detected (Rhizoctonia; S. Avila, pers. comm.) in paddocks with previous history of having showing brassicas. In general, individual performance and productivity per unit of land achieved during vegetative and early mature stages showed the potential of brassicas a as summer feed source for finishing lambs.

Table 3. *Texel lambs performance grazing brassica crop cv Pasja in three different periods (Adapted from Ayala et al., 2007).*

	Variables	Stocking rate (lambs/ha)			
		24	36	48	60
Vegetative (22/01-23/02)	Herbage allowance (DM kg/an/day)	8.7	6.2	5.7	3.0
	Liveweight gains (kg/an/day)	0.177	0.224	0.214	0.235
	Liveweight (kg/ha)	136	258	329	451
Early mature (23/02-20/03)	Herbage allowance (DM kg/an/day)	10.1	9.5	6.6	5.6
	Liveweight gains (kg/an/day)	0.248	0.205	0.212	0.176
	Liveweight (kg/ha)	149	185	254	264
Late mature (20/03-02/04)	Herbage allowance (DM kg/an/day)	19.3	19.5	13.1	--
	Liveweight gains (kg/an/day)	0.096	0.092	0.012	--
	Liveweight (kg/ha)	30	43	7	--

Adjusted models: yLWG vegetative=-6.5 x^2+48.9 x +139, r^2=0.80; yLW vegetative= 101.6x+39.5; r^2=0.99 yLWG early mature=0.0209x+02625, r^2=0.83; yLW early mature=41.4x+109.5; r^2=0.93 yLWG late mature: adjusted model was not found; yLW late mature: adjusted model was not found

Another study including the option of using an adjacent natural grasslands area as a fiber source to the brassica crop was added to give the animals the opportunity to balancing the diet by promoting animal selection. In the context of extensive systems of Uruguay, this management practice could simplify labor use and operational costs. Four stocking rates (72, 60, 48 and 36 an/ha) were evaluated with Corriedale lambs, having each one a grazing area composed of 68% of brassica crop cv. Goliath and 32% of a native pasture. Animal behavior was not affected by stocking rates. Animals dedicated 62% for grazing of the total time evaluated (measured

between 6:15 am to 7:30 pm), being 59% of the time of grazing concentrated on the brassica area (P<0.05). Grazing patterns on brassica crop were more important on late afternoon (4:00 pm – 7:30 pm) in comparison with other periods of the day. Comparatively, animals trend to select other species instead brassica, showing strong pattern at advanced mature stages of the crop. The recommended size of native grassland should be minimal (<32%), and is critical in terms to force animal to utilize efficiently brassica crop.

The brassica crop cv. Graza showed a high degree of adaptation in the north region of Uruguay, based on the heat stress tolerance of this cultivar. However, it is extremely sensible to extreme rainfall regimes. At "Glencoe" Experimental Unit, INIA Tacuarembó, the cv. Graza was evaluated with weaning calves weighing 98 kg/an during 80 days, comparing two stocking rates (8.4 and 12 an/ha). During the first 26 days, calves were supplemented (1% of liveweight). During this time, animals avoided grazing brassica, affecting individual performance (Table 4), contrasting with the results of lambs which had high preference for this crop like was observed in other trials.

Table 4. *Pre and post grazing herbage mass and liveweight gain of weaning calves grazing brassica crop cv. Graza during summer (R. Cuadro et al., unpublished data).*

Treatment (lambs/ha)	Pre grazing herbage mass and sward height		Post grazing herbage mass and sward height		Liveweight gains
	Height (cm)	Dry matter (t/ha)	Height (cm)	Dry matter (t/ha)	(kg/an/day)
8.4	13	3.5 a	9	3.2 a	0.292 a
12	14	3.3 a	7	2.7 b	0.233 a

Different letters in columns show differences between treatments (LSD; P<0.05).

Another trial with weaning calves weighing of 102.7±6 kg/an was conducted at "Palo a Pique" Experimental Unit, INIA Treinta y Tres, Uruguay by Ayala et al. (2007) over a brassica crop cv. Goliath. Individual performance, managing 11 an/ha, achieved 0.479 kg/an/day and it was increased to 0.835 kg/an/day when animals were supplemented with 1 kg/an/day of a protein supplement. Animals needed an adaptation period, but later grazed cv. Goliath without restrictions, showing important differences in preference in favor of this cultivar in comparison with previous trial using cv. Graza.

c) Plantain

Plantago lanceolata is a perennial herb, distributed in temperate regions (Stewart, 1996). It is recommended as an alternative pasture for less fertile environments, also described as a drought tolerant species. It was recently introduced in Uruguay, the evaluation has been focused on testing its adaptation to less fertile soils and its potential to finishing lambs in summer.

A trial using the plantain cv. Ceres Tonic was established to evaluate the carrying capacity of this forage during summer (Barrios, 2006). Treatments included four stocking rates (10.5, 13.2, 15.8 and 18.4 an/ha) applied during 97 days from December to March, grazing two paddocks alternatively each two weeks (Table 5). Rainfall regime was 25% under the long term average of the experimental site. Results showed an adequate degree of adaptation to the climatic conditions of the eastern region and the tolerance to drought conditions registered. Plantain growth rates were in average 44.6 kg DM/ha/day. A negative correlation between stocking rate and liveweight gains was measured ($P<0.001$), reducing liveweight gains by 0.0202 kg/an/day per each additional lamb/ha over a stocking rate of 10.5 an/ha. Concluding, the stocking rate of 15.8 an/ha was the best alternative for balancing adequately individual performance and productivity per hectare and finished lambs according to the market requirements for heavy lambs in Uruguay. These levels of productivity are very promising in comparison with those obtained with traditional legumes (lotus, red clover) used in summer.

Table 5. *Animal performance of Corriedale lambs at four stocking rates grazing Plantain cv. Ceres Tonic from December to March (Adapted from Barrios, 2006).*

Variables	Stocking rate (lambs/ha)			
	10.5	13.2	15.8	18.4
Herbage allowance (DM kg/an/day)	2.3	1.3	1.2	1.0
Liveweight gains (kg/an/day)	0.226	0.188	0.190	0.158
Liveweight (kg/ha)	231	240	291	282

Adjusted models: $yLWG = -20x+241$, $r^2=0.8783$; $yLW = -4.75x^2+44.05x+187.75$; $r^2=0.8144$

However, defoliation management of Plantain is not well understood. A trial to evaluate the effect of defoliation frequency, intensity and the impact of winter grazing on the production, morphology and plant population was also established. Over a three year old pure stand under grazing, there were contrasted three intensities of defoliation (2, 7 and 12 cm postgrazing heights) combined with two frequencies (21

and 42 days for grazing intervals) with or without winter grazing. Initial plant population was 96±23 plants/m^2, being reduced significantly over experiment ($P<0.01$). In October and December, there were no changes in plant population. In March, there were significant differences ($P<0.05$) as a consequence of previous winter grazing, with 32.2 % fewer plants in plots grazed in winter. Final population declined by 68 and 78% for non winter grazing and winter grazing treatments, respectively. Shoot/m^2 and shoot/plant were not affected by treatments. Shoot diameter was reduced over time ($P<0.05$), being affected by grazing intensity in September ($P<0.05$), with shoot diameter of plants defoliated at 2 cm height being lower than the other treatments. Crown dry weight was affected by grazing intensity in September ($P<0.01$), being 49, 66 and 39 g/m^2 for 2, 7 and 12 cm height. Plant crown diameter of treatments defoliated at 7 cm height was higher than those defoliated at 12 cm height. Preliminary results showed a negative effect of winter grazing on plant population and for defoliation intensity on plant size. Plant population also declined over time independently of the grazing management applied. Probably, pasture age and rainfall regime contributed to plant stand reduction, which are areas of study that should be attended in future research.

d) Setaria

Setaria sphacelata is a perennial C_4 grass (Jank and Hacker, 2004), native to subtropical Africa, and commonly used in other subtropical environments of Asia, Australia (Cook et al., 2005) and America. It was introduced to Uruguay in the 1970's with other forage subtropical grasses and legumes (Mas, 2007). Adapted to a wide range of soils and environments, it shows high herbage production, persistence and low temperature tolerance compared with other subtropical grasses. Annual biomass yield ranged between 8.8 and 13.8 t DM/ha which was reported in New Zealand, under normal conditions, increasing from 13 to 18.9 t DM/ha under irrigation (Taylor et al., 1976). In lowland areas of eastern Uruguay, Mas (2007) reported yields from 6 to 18 t DM/ha. Nitrogen applications increase herbage yield, achieving responses of 27 kg of DM/kg of N applied (Pérez Gomar et al., 2010). Rotational grazing management is recommended with high stocking rates and regrowth periods of 35 days (Roig, 2003). However, no differences in steer liveweight gains were detected in Australia when continuous and rotational grazing regimes were compared (Evans and Hacker, 1992).

Forage and liveweight production of *Setaria sphacelata* cv. Narok were evaluated for different stocking rates under irrigation in Uruguay (Pravia, 2009). Rotational grazing was performed in four complete cycles of 42 days each (7 days of occupation and 35 of regrowth) from November 2008 to April 2009, with steers of 332±29 initial liveweight kg/an (Table 6). Nitrogen fertilizer was spread after each grazing period, totalizing 220 kg urea/ha. Irrigating was applied only when was needed according to soil moisture conditions. Three grazing intensities were evaluated over the period (low, medium and high, corresponding to 2.5, 3.6 and 5 an/ha in the gazing cycles 1 and 2, respectively and raising to 2.5, 4.85 and 7.5 an/ha in cycles 3 and 4). Total herbage production averaged 14.4 t DM/ha, with no significant differences between stocking rates. Daily forage growth rates were 54, 89 and 86 kg DM/ha/day for each 35 day intervals between grazing cycles 1-2, 2-3 and 3-4, respectively.

Produced liveweights/ha were 224, 372 and 345 kg/ha for low, medium and high stocking rates, respectively. There were no differences in liveweight gain per animal between low and medium stocking rates, while high stocking rates had an average of 35% lower gains per animal in comparison with the animals of the other treatments. High liveweight gains were registered during the vegetative stage of the sward in November (0.9-1 kg/an/day), declining through the reproductive stage. Liveweight gains per animal averaged 0.7 kg/an/day for low and medium stocking rates in grazing cycles 1 and 2 (Table 6), finally dropping to 0.36 kg/an/day in cycles 3 and 4. These results agree with those reported by Jones (1989) in Australia, where liveweight gains ranged between 0.316-0.510 kg/an/day managing 5 steers/ha in a 4 year study.

Table 6. *Liveweight gains and production/ha of Hereford and Hereford x Angus steers grazing Setaria sphacelata cv, Narok under different stocking rates (Adapted from Pravia, 2009).*

Treatments (Steers/ha)	Initial liveweight (kg/an)	Liveweight gains (kg/an/day)	Liveweight (kg/ha)
Period:11/11/2009 – 3/02/2009 Cicles 1 and 2			
Low - 2.5	332	0.704a	148
Medium - 3.6	327	0.730a	221
High - 5.0	338	0.458b	192
Period:3/02/2009 – 28/04/2009 Cicles 3 and 4			
Low - 2.5	391	0.361a	76
Medium - 4.85	390	0.371a	151
High - 7.5	375	0.242b	153

Different letters showed differences within periods (LSD, P<0.05)

Overall, Setaria proved to be an interesting alternative for high summer forage production under soil and weather conditions of Uruguay. High biomass growth rates can be achieved by irrigation and nitrogen fertilization, requiring varying stocking rate for adjusting the differences in seasonal growth or eventually by applying topping. Changes in forage nutritive value along the grazing season affect animal performance, and as a consequence, moderate liveweight gains per animal are observed. However, high levels of animal production can be obtained per land unit when production systems are based on moderate to high stocking rates. This is particularly interesting in rice-pasture mixed systems, which are common in lowland areas of eastern Uruguay, where pasture areas are reduced during rice growing season and by summer tillage. Including a small area of this kind of perennial pasture, could have strategic results for the whole farm production system. It would give higher stability of pasture production through different seasons, and also allow resting for temperate pastures utilization during the summer, leading to better management of the whole farm system.

e) Sorghum

Sorghum sudanense is an annual summer grass, commonly used in Uruguay in beef and dairy systems for grazing, silage, green chop or hay. It shows a production potential over 9 t DM/ha with high quality in early stages, allowing the first grazing after 45 days of sowing and three extra grazing cycles over the rest of the season on average. In INIA Treinta y Tres, Uruguay, research studies including crop utilization for beef fattening systems, managing residual herbage mass and regrowth, fertilization and protein supplementation. Animal performance in early stages of the crop achieved steers liveweight gains of 0.900 kg/an/day managing a stock of 1500 kg LW/ha, under rotational grazing system with resting periods of 25 days. On average grazing season of 85 days length could be expected liveweight production goals of around 270 kg/ha. Individual performance tends to decline over the season (second and third grazing) turning down to 0.300 kg/an/day, as a consequence of reduction in forage quality.

Considering variations in summer climatic regimes, some studies evaluated steers performance grazing sorghum, combined with natural or artificial shade to reduce heat stress during summer (Rovira and Velazco, 2009). First, a characterization of climatic conditions during summer, determined that an index that includes humidity

and temperature is a good predictor of conditions that predispose animals to heat stress. Treatments included different strategies of shade access (no shade, restricted shade between 11 am-4 pm, natural or artificial shade). Results showed the shade effect improved significantly animal performance of steers grazing sorghum when feed is no limiting and arising conditions for heat stress, not being significant differences as a consequence of type of shade used. Shade contributed to reduce breathing and not affected significantly grazing sessions. Similar experiments have been performed with early weaning calves at INIA "Glencoe" Experimental Unit, where there were no differences in liveweight between treatments with or with access to shade or comparing the type of shade (artificial or natural) (Montossi et al., pers. comm.).

Opportunities and challenges

A series of changes are operating in the agricultural sector of Uruguay. A high international demand for grains, meat and forestry products determine competitive forces between sectors around land use. In this context livestock production needs to be reoriented for being more competitive with cropping or forestry. At the same time, increasing climatic extreme conditions are raising productive, environmental, social and economical risks for livestock sector.

More emphasis is taking place in looking for technology options to solve forage and animal summer limitations, which are leaded by the Uruguayan Research bodies. These are focused on reducing summer variability, in terms of quantity and quality forage supply, where a set of forage species have been evaluated and the results are reported in this paper in different regions and for different systems. Table 7 summarizes the advanced achieved and explored.

Table 7. *Productive performance, nutritional value and use of alternative summer species for animal production.*

Cycle	Species		Forage production	Nutritive value	Specially recommended for
Annual pastures	Brassicas		++	+++	Sheep/Beef/Dairy
	Sorghum sudanense		+++	+	Beef/Dairy
Perennial pastures	Legumes	Red clover	++	++	Sheep/Beef/Dairy
		Lotus	+	++	Sheep/Beef/Dairy
	Herbs (Plantain)		+	++	Sheep/Beef
	Grasses (Setaria)		+++	+	Beef

Reference: + (low), ++ (medium), +++ (high)

From forage research, in order to face the changes of productive scenarios

predicted, some mitigation, adaptations and management practices have to be considered, particularly focused on the more extensive beef and sheep production systems, addressing: a) increase forage production and quality with traditional and novel species and agronomic practices, b) combinations of production systems (cropping, pasture, animal production, forestry, etc.), c) forage irrigation, d) plant breeding for reducing seasonal variability, e) cake of livestock welfare, f) promote soil, water and air sustainability, g) climatic change, h) ecological variation in different regions of Uruguay, and i) increase efficiency.

In conclusion, from the forage research point of view the use of alternative species for specific animal productive purposes in the different productive systems has been clearly addressed, and more challenges have to be faced in the near future, thinking in the short, medium and long term.

REFERENCES

Ayala, W. 2001. Defoliation management of birdsfoot trefoil (Lotus corniculatus L.). Thesis presented for the degree of doctor of Phylosophy in the Institute of Natural Resources. Massey University, New Zealand, 228 p.

Ayala, W.; Bermúdez, R.; Barrios, E. 2007. Utilización de brassicas (nabos forrajeros) en la recría-engorde de corderos Texel durante el período estival. Resultados preliminares. In: Cultivos y Forrajeras de Verano. Unidad Experimental Palo a Pique. INIA Treinta y Tres Serie Actividades de Difusión 538, 49-59.

Ayala, W.; Barrios, E.; Velazco, J.; Bermúdez, R. 2008. Utilización de nabos forrajeros en engorde de corderos y destete de terneros durante el verano. Resultados 2007-2008. In: Jornada de Divulgación de Producción Animal-Pasturas. INIA Treinta y Tres Serie Actividades de Difusión 591, 21-28.

Ayala, W.; Barrios, E.; Bermúdez, R.; Montaño, A. 2009. Efecto de la carga animal en la performance de corderos Corriedale pastoreando nabos forrajeros durante el período estival. In: Jornada de Divulgación de Producción Animal-Pasturas. INIA Treinta y Tres Serie Actividades de Difusión 591, pp. 21-28.

Barrios, E. 2006. Efecto de la carga en el comportamiento productivo de corderos pastoreando Plantago lanceolata. Trabajo de Pasantía, Escuela Agraria La Carolina, Flores, Uruguay, 73 p.

Barrios, E.; Ayala, W.; Bermúdez, R. 2007. Novedades forrajeras: Uso de llantén (Plantago lanceolata) en engorde ovino. In: Jornada Anual Unidad Experimental Palo a Pique. Serie Actividades de Difusión 511, 15-21.

Cook, B.G.; Pengelly B.C.; Brown, S.D.; Donnelly, J.L.; Eagles, D.A.; Franco, M.A.; Hanson, J.; Mullen, B.F.; Partridge, I.J.; Peters, M.; Schultze-Kraft; R. 2005. Tropical Forages: an interactive selection tool, [CD-ROM], CSIRO, DPI&F (Qld), CIAT and ILRI, Brisbane, Australia.

Evans, T.R.; Hacker, J.B. 1992. An evaluation of the production potential of six tropical grasses under grazing. 3. Responses to set stocking rates under continuous grazing. In: Australian Journal of Experimental Agriculture 32, 693-699.

Garret, B.C.; Westwood, C.T.; Nichol, W.W. 2000. Optimising animal production from Forage brassicas. "Capturing value". In: Proceedings of the New Zealand Institute of Primary Industry. Management Conference 2000. Applied Management and Computing Division, Lincoln University, 61-73.

Jank, L.; Hacker, J.B. 2004. Setaria. In: Moser, L. E., B. L. Burson and L. E. Sollenberger (ed). Warm season (C4) grasses. American Society of Agronomy, Crop Science Society of Agronomy, Soil Science Society of Agronomy. Madison, Winsconsin, USA. Series of Agronomy, Monograph 45, 785-807.

Jones, R.J. 1989. Nitrogen-fertilized pastures of Narok setaria and Samford rhodes grass give similar beef production in S.E. Queensland. Tropical grasslands (23) 2, 65-74.

Mas, C. 2007. Setaria sphacelata. Una gramínea a tener en cuenta. In: Revista INIA. Instituto Nacional de Investigación Agropecuaria. Revista N° 10 Abril 2007. ISSN 1510 0911.

Nichol, W.W.; Garret, B.C. 2001. Optimising prime lamb production on summer brassica crops. In: Proceedings of the World Sheep Congress 2001, 7 p.

Pérez Gomar, E.; Silveira, M.; De Matos, C.; Balparda, C. 2010. Setaria, una alternativa forrajera perenne estival para sistemas ganaderos en suelos de Basalto. In: Después de las lluvias. Desafío de producción animal y forraje para los próximos meses. Día de campo INIA Tacuarembó.

Pravia, V. 2009. Utilización de Setaria sphacelata cv Narok bajo riego con diferentes dotaciones de novillos. In: Jornada de Divulgación de Producción animal-Pasturas. INIA Serie Actividades de Difusión 591, 13-20.

Reid, R.L.; Puoli, J.R.; Jung, G.A.; Cox-Ganser, J.M.; McCoy, A. 1994. Evaluation of brassicas in grazing systems for sheep. I: Quality of forage and animal performance. In: Journal of animal Science 72, 1823-1831.

Roig, C. A. 2003. Setaria sphacelata cv. Narok. In: Pastizales y pasturas cultivadas. INTA Colonia Benítez. http ://www.inta.gov.ar/benitez/info/documentos/pastura/art/past06.htm verificado 11/22/2007.

Rovira, P. Velazco, J. 2009. Efecto del tipo de sombra en la ganancia de peso, tasa respiratoria y conducta de novillos en pastoreo. In: Jornada de Divulgación de Producción animal-Pasturas. INIA Serie Actividades de Difusión 591, 83-94.

Stewart, A. 1996. Plantain (Plantago lanceolata) - a potential pasture species. In: Proceedings of the New Zealand Grasslands Association 58, 77-86.

Taylor, A.O.; Rowley, J.A.; Hunt, B.J. 1976. Potential of new summer grasses in Northland. I. Warm-season yields Ander dryland and irrigation. In: New Zealand Journal of Agricultural Research 19, 127-133.

Travasso, M. I. 2008. Cambio climático y producción forrajera en el noreste argentino. In: XXII Reunión del grupo técnico en forrajeras del Cono Sur. Bioma campos: innovando para mantener su sustentabilidad y competitividad. Minas, Lavalleja, Uruguay, 47-53.