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in

Cantero-Martínez C. (ed.), Gabiña D. (ed.).
Mediterranean rainfed agriculture: Strategies for sustainability

Zaragoza : CIHEAM
Options Méditerranéennes : Série A. Séminaires Méditerranéens; n. 60

2004
pages 231-261

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SUMMARY – This paper summarises the results of the evaluation of technologies well adapted to improving the sustainability of animal production systems, especially small ruminants, in Mediterranean rainfed conditions. Technologies have been evaluated at research, demonstration and on-farm levels. The correct management of rangelands, with fertilisation, reseeding and grazing management; new forages, including shrubs; feed blocks; and the utilisation or the improvement of the quality of some agricultural by-products can provide valuable nutritional resources. Correct reproduction planning and the use of techniques such as the "ram effect" have proven to be a way to improve the reproductive performances. Genetic improvement, through selection or cross-breeding, can be another important tool to improve traits of economic importance. Finally, some of the technologies evaluated, such as the use of fences or complete low-cost rations, have shown to be useful when the availability of labour is a limiting factor for the production system.

Key words: Mediterranean, rainfed agriculture, animal production, technologies.

RÉSUMÉ – *"Technologies pour la production animale". Cet article résume les résultats de l'évaluation de technologies bien adaptées en vue d'améliorer la durabilité des systèmes de production animale, spécialement pour les petits ruminants, en conditions pluviales méditerranéennes. Ces technologies ont été évaluées au niveau de la recherche, de la démonstration et de la ferme. La conduite correcte des parcours, avec fertilisation, gestion du réensemencement et du pâturage ; les nouveaux fourrages, y compris les arbustes ; les blocs alimentaires ; et l'utilisation de certains sous-produits agricoles ou l'amélioration de leur qualité peuvent apporter d'intéressantes ressources nutritionnelles. Une planification correcte de la reproduction et l'utilisation de techniques telles que "l'effet mâle" ont prouvé être une façon d'améliorer les performances reproductives. L'amélioration génétique, à travers la sélection ou le croisement, peut être un autre instrument d'importance pour améliorer les caractères d'intérêt économique. Finalement, certaines des technologies évaluées, telles que la mise en défens ou des rations complètes à faible coût, se sont montrées d'utilité lorsque la disponibilité en main-d'œuvre est un facteur limitant pour le système de production.*

Mots-clés : *Méditerranée, agriculture pluviale, production animale, technologies.*

Present technical problems and alternatives for the group of technologies

Sheep and goat farming are the most characteristic animal production systems in the Mediterranean area. They constitute a traditional activity of great economic, social and environmental importance, with populations of around 170 and 40 million head respectively. This production plays a very important role in the use of marginal zones, by-products and forage resources that are not used by other species, which often gives rise to extensive or semi-extensive production systems. Most Mediterranean sheep and goat populations are constituted by local breeds, well adapted to the environmental conditions, generally with a low production, due in part to a genetic adaptation to harsh environments and to the shortage of inputs, particularly feed. Nevertheless, their products are normally considered to be of high quality and on many occasions are subject to norms for their characterisation, control and protection.

However, the Mediterranean sheep and goat farms are not in many cases economically profitable, as they do not guarantee the farmers a minimum income, unlike other arable or livestock speculations or when compared with other economic sectors. This is conditioning the future and the sustainability of these production systems.

These systems can be improved in several ways. The improvement of the feed resources is the most fundamental as these resources are the limiting factor for the increase in productivity in most situations. On the other hand, a better management of reproduction can improve flock productivity and labour efficiency as well as commercial margins, as lambing and kidding can be concentrated to coincide with lamb sales during favourable price periods. Genetic improvement can also permit an improvement in flock profitability as by producing genotypes capable of producing in difficult environments or more productive genotypes that can be used for situations in which feed resources are no longer the main limiting factor. Finally, and although this group of technologies is not evaluated in the project, the improvement of the hygiene and health conditions in the flocks is an essential condition for the increase of productivity and efficiency.

Within this framework, the animal production technologies evaluated in this project have been the following:

(i) Rehabilitation and improvement of native pastures.

(ii) Forage alternatives.

(iii) By-product quality improvement.

(iv) Feeds.

(v) Control of reproduction.

(vi) Genetic improvement in sheep.

(vii) Genetic improvement in goats.

(viii) Young camel artificial rearing.

Technology 1: Rehabilitation and improvement of native pastures – steppe management and conservation

Description of the traditional/conventional technology

Common village grazing areas are a feature of the Mediterranean area. Their quality is usually poor since they are used throughout the year and many times with high stocking rates.

Objective of the alternative technology

Fertilising, grazing management and reseeding practices that sustain the productivity of native pastures, conserve the biodiversity of the native flora and integrate traditional common property rights.

Description of the alternative technology

Several practices are possible: (i) application of phosphate fertiliser; (ii) reseeding practices; (iii) appropriate grazing management practices; and (iv) combination of the previous practices (fertilisation, reseeding and grazing management).

Summary of results

At research and experimental level

Application of phosphate fertiliser

Syria. Osman *et al.* (1991, 1994). Three levels of phosphate fertiliser application (0, 25, 60 kg/ha) and two stocking rates were applied to grazing lands typical of villages in Syria. Phosphate application increased total biomass production, the percentage of legumes in the biomass (up to 180 and 200% with 25 and 60 kg of phosphate/ha compared to no fertilization), the total milk yield (up to 17 and 36%) and reducing the costs of feeding (up to 72 and 65%).

Reseeding practices

Syria. Osman *et al.* (1996). Comparison of native (unimproved) and improved (direct seeded with *Atriplex halimus* and *Salsola vermiculata*) steppe. Grazeable biomass (kg/ha) improved up to 531, 703 and 467%, respectively, with stocking rates of 2.25, 1.5 and 0.75 ha/ewe while milk yield (kg/ha) increased 115, 150 and 36% respectively.

Combination of fertilisation, reseeding and grazing management

Turkey. Büyükburç (1983), Büyükburç (1984) and Fırıncıoğlu and Unal (unpublished data). Experience with natural reseeding of range species, 50 kg/ha nitrogen and phosphorous application in spring and autumn, and a grazing management in which the grazing area is divided in two. Dry matter (DM) yield increases from 500-700 kg/ha to 1500-2100 kg/ha at the end of the six-years.

On-farm trials

Combination of fertilisation and reseeding

Syria. Ghassali *et al.* (1999) compared an unimproved area with an area improved by reseeding with clovers (*Trifolium* spp.) and medics (*Medicago* spp.) and phosphate fertiliser. Total herbage production (kg DM/ha) increased from 36 to 76%.

At farmer level. On farm surveys

Surveys for users have been carried out in three countries, Egypt (4 surveys), Morocco (10) and Spain (4). The average age of surveyed farmers is, respectively, 39.3, 55.7 and 40 years. The educational level is 100% primary education in Egypt, 60% illiterate and 40% primary education in Morocco, and 25% primary and 75% secondary education in Spain. The average size of flocks is 1155, 221 and 783 head respectively.

The investment needed and the technical and economic results have only been quantified in Spain; investment is 664 €/ha, which is considered medium (50%) or low (50%). Regarding technical results, there are no differences in productivity (1.2 lambs sold/ewe/year). Labour productivity is higher in users than in non users (628 vs 465 ewes/MPU – Man Power Unit). This difference is reflected in a reduction of labour costs (3.7 vs 6.6 €/ewe/year) although the total cost/ewe is higher for users (84.8 vs 78.6 €/year).

Surveys for non users have been conducted only in Spain (4 surveys). The farmers are older than users (43.9 years) and with a lower level of education (6% illiterate, 67% and 28% secondary education). They also own big flocks (1006 head). The high investment needed (22%), the non profitability and the difficulties to implement the technology (22%) have been the main reasons for the non adoption.

Similarity and differences between sites

Adequate use of fertilisation, reseeding and grazing management or the combination between these technologies has a positive effect in all locations.

Conclusions

Improvement

(i) Reduce feed deficit.

(ii) Conserve native pastures and species diversity.

(iii) Reduce soil and water erosion.

Disadvantages/limitations

(i) Difficult to implement rehabilitation on an individual basis since common village grazing is open access.

(ii) High cost of collecting and preparing seed for rehabilitation.

(iii) Farmers prefer to apply phosphate fertiliser to arable land.

Conditions of use

Plan/agree at community level on rehabilitation programme and management, to include collection and preparation of seed, reseeding of selected areas, closing of areas to allow recovery of pastures, access calendar for different areas, number of animals to be carried, procedures to settle disputes, etc.

Recommendations

Seek collaboration and convince potential users so that the experience will last**.**

Technology 2: Forage alternatives for Mediterranean rainfed areas

Description of the traditional/conventional technology

The classical feeding alternative in Mediterranean rainfed areas is a combination of grazing spontaneous vegetation grown in the fallow areas in autumn and spring, agricultural by-products grazed from cereal stubble, forages cultivated in irrigated areas and cereals provided in the feeder.

Objective of the alternative technology

To develop a feeding strategy based on forages adapted to extensive rainfed Mediterranean sheep systems. Pasture, hay, grain and straw are considered as source of feeding. Fallow areas are used for this forage production in many cases. Another objective may be overcoming the shortage of labour, especially shepherds.

Description of the alternative technology

The alternative technology and the mode of implementation is diverse.

Spain. Delgado (2000). Four different sources of forage: cereals, alfalfa, *Lolium rigidum* + annual medics and *Atriplex halimus* bushes divided into four equal plots. The annual use of crops for grazing

is established through a fixed calendar: cereals, from February to September; *Lolium rigidum* + annual medics, March and July; alfalfa, from April to June; and *Atriplex halimus,* November, December and January. All plots are fenced.

Turkey. Elicin *et al.* (1983) and Cangir *et al.* (1984). Barley + vetch grown on the fallow. Sown in winter or spring.

Syria. Seed of suitably adapted species of annual forage legumes [vetches (*Vicia* spp.), chicklings (*Lathyrus* spp.) and peas (*Pisum* spp.)] is sown in late autumn once soil moisture levels are adequate. The forages are grazed in spring by weaned lambs or conserved as hay, grain and straw for use in winter by pregnant and lactating ewes and does. In the "ley farming system" scarified seed of suitably adapted self-regenerating pasture legumes of annual Medicago (e.g. *M. rigidula*, *M. polymorpha*) is sown in early winter following a barley or wheat crop. Lactating ewes and does start grazing the "medic" pastures as early as February if good pasture establishment is followed by good winter growth. They graze through spring into summer but grazing of the dried residues stops at a suitable time to leave sufficient pods for the self-regeneration phase. A wheat or barley crop is then sown at the start of the next cropping season and harvested the following summer. When there is sufficient moisture at the start of the following cropping season the seed in the medic pods germinates and establishes a new pasture. (Hence the term self-regenerating pastures.)

Summary of results

At research and experimental level

Spain. Delgado (2000). A stocking rate of 2 ewes/ha has been maintained without any supplementation for 8 years with an annual rainfall average of 392 mm. With a reproduction system of one mating season/year (October), the number of lambs sold/ewe/year has been 1.17 and the number of lambs sold/ha/year 2.5, with a fertility of 92%, a prolificacy of 1.31 and a lamb mortality of 3.6%. Labour is limited to health and animal movement operations (weaning, change of plots, etc.) with a very high efficiency. The difference in lamb price with conventional lambs, fed on concentrates may be positive (as "ecological lamb") or negative (red colour on the carcass). The estimated cost of fencing/ewe is 37.5 euro, which can be quickly compensated by the elimination of the shepherd's salary and no concentrate consumption.

Syria. Veen (1967) and Rihawi *et al.* (1987). Lambs grazing oat/vetch (*V. sativa* spp. *dasycarpa*) mixture grown on fallow land rotated with wheat increased net income/ha by 88% provided adequate phosphate fertiliser applied. Growth rates were 98 (44 grazing days) and 127 g/d (15 grazing days) respectively for oats/V*. dasycarpa* and barley aftermath grazing. DM hay total yields (kg/ha) have varied from 8147 (in 1983) to 4377 (in 1984) in a barley/vetch to changes in rainfall (322 and 229 mm respectively).

Turkey. Elicin *et al.* (1983) and Cangir *et al.* (1984). Grazing the barley + vetch mixture spring-grown in the fallow and without concentrates allows similar growth rate in lambs as with the classical feeding on concentrates. Providing 500 g/d of concentrates increases growth rate in 10% compared with lambs fed on concentrates, with a reduction of 68.5% in the consumption of concentrates. For the winter-grown mixture there is a decrease in growth rate (-40 and -22%, respectively for non concentrates or 500 g/d).

At farmer level. On-farm surveys

Syria. Compared to the classical barley/fallow system, net revenue/ha can increase from 357 to 119% in a barley/vetch rotation and from 357 to 168% in a barley/chickling (Thomson *et al.,* 1992). Compared to the classical barley-fallow, DM yields, protein yield and energy yield increased 66, 64 and 67% respectively for a continuous barley rotation, 83, 138 and 75 for barley/vetch and 72, 133 and 75 for barley/chickling (Christiansen *et al.*, 2000).

Similarities and differences between sites

With the particularities of each site, it has been shown that forage production in Mediterranean rainfed areas is possible and can be profitable.

Conclusions

Improvement

(i) Important forage production can be obtained.

(ii) Important savings on concentrates can be achieved.

(iii) Other input reduction if fenced areas are established.

(iv) Reduction of erosion.

Disadvantages

(i) High and costly labour needs if harvested such as hay, grain and straw.

(ii) Cost of the fences.

Limits

(i) Availability of seed, phosphate fertiliser and harvesting machines.

(ii) Trespassing of flocks on pastures.

Conditions of use

Training programmes provided for extension workers and farmers.

Recommendations

(i) Commitment by governments to promote the use of forages, such as strengthening the extension service, holding training courses for farmers and making seed, harvesting machines and credit available through the private sector.

(ii) Forage global alternatives can be recommended for Mediterranean rainfed areas where cereal crops are not a profitable alternative and where there are farms with big enough plots. However, as large investments are required, the technique can be recommended when the amortization period is long enough to be compensated by the reduction in labour costs.

Technology 3: Fodder shrubs as alternative forages for Mediterranean rainfed areas

Although fodder shrubs could be considered within the technology 2 and in fact they are included in some of the alternatives, their presentation as alternative forages is made separately due to their special characteristics in terms of establishment and management.

Description of the traditional/conventional technology

Same as technology 2.

Objective of the alternative technology

The objective of this technology is to bring new alternative non-conventional feed to stockholders that can be used when conventional feed is lacking.

Conservation and preservation of natural resources is also an important objective.

Description of the alternative technology

The present trend for establishing shrubs (Le Houérou, 2002) consists in planting them in cereal fields. The shrubs are thus protected from browsing by the presence of the cereal. After the harvest, livestock are allowed to graze the stubble and browse the shrubs. The optimum density is 2000 shrubs/ha.

Summary of results

At research and experimental level

Spain. Delgado (2000). Three years after being planted, the annual production of utilisable forage has been from 0.9 to 2.0 t DM/ha with a rainfall between 306 and 585 mm. The stocking rate has been around 2.2 during the three months of utilisation (November, December, January).

Syria. ICARDA (2000). A pilot study using Awassi castrates fed with *A. Halimus* (AH)*, A. Nummularia* (AN), *A. Canescens* (AC)*, A. halimus* + barley straw (BS), *A. nummularia* + BS, *A. canescens* + BS and a mixture of AH, AN and AC indicated that despite the high intakes, the castrates lost live weight and when barley straw was offered the live weight changes were similar. It was concluded that a source of energy was needed in the diet.

Morocco. Ayadi (1996). Comparison of ewes grazing *A. Nummularia*, supplemented or otherwise with concentrates (600 g/d a mix composed of barley, dried sugar beet pulp, sunflower cake and mineral complement). Results are lower in non-supplemented ewes, for weight of the ewe at the end of pregnancy (2.9%), weight of the ewe at the beginning of lactation (17.1%), weight of the ewe at the end of lactation (17.8%), milk production (10.8%), weight of lambs at birth (24.4%) and average daily gain (ADG) of lambs in the suckling period (4.4%).

On-farm trials

Syria. Jones and Arous (2000). 6-year trial of inter-cropped fodder shrubs in an area receiving a mean rainfall of 267 mm. Area percentages for barley and *Atriplex* varied from 81 to 63% and from 19 to 37%. Hedge/strip type had little if any effect on total biomass yields of barley (1.51 to 1.87 t/ha) and *Atriplex* (saltbush) (0.52 to 0.89 t/ha). Annual variations of barley and atriplex yields behaved independently such that total inter-year variability in biomass yield was reduced. The presence of *Atriplex* hedges stabilised annual feed output. Phosphate given to shrubs had a significant benefit.

At farmer level. On-farm surveys

Syria. Leybourne *et al.* (1997). Survey of farmers in the steppe who complied with a law passed in 1983, permitting them to sow up to 45 ha barley provided they agreed to establish fodder shrubs on 30% of the area. Social acceptance: farmers had a low opinion of the shrubs and would have preferred to sow barley. Level of adoption: of the estimated 1350 farmers who received seedlings from the government during the mid-1980s, only an estimated 31% still had plantations in 1993.

Syria. Hamadeh *et al.* (2000). In a grazing trial using steppe improved with fodder shrubs, the shrubs can provide up to 40% of the diet of sheep and sometimes as low as 6% depending on the month; but large differences in the contribution of the shrubs between years in the same months are reported.

Summary of results by Le Houérou (2002)

In the publication by Le Houérou (2002), the morphological and adaptive characteristics of the most used fodder shrubs are presented and a summary of the results of their utilisation is made.

Various experiments show that the shrub uptake may rise from the classical value of 600-800 g DM/head/day to 1600-2000 g DM/head/day, within a time span of 3 months with unadjusted animals. With adjusted animals these levels are observed since the inception of the feeding trials. It has furthermore been shown that animals can be exclusively fed with shrubs all year long with body weight gains up to 100 g DM/head/day or simply maintained in good condition, depending on the management scope

But with nitrogen-deficient shrubs, such as cacti, a cheap source of nitrogen must be added, in the form of urea and some energy from roughage such as straw, for a maintenance ration. Nitrogen deficiency can also be corrected by soil fertilising.

A synergic effect of shrub feeding was observed since the consumption of multi species rations was always superior to the consumption of any single species, the same conclusion applied to animal performance.

It is shown that fodder shrubs are a profitable feed alternative to barley grain in most situations. The more intensive the fodder shrub production system is, the more profitable it becomes in terms of cost/benefit ratio per unit of feed produced.

Establishment by direct seeding of pre-germinated seeds is the most promising technology. One of the reasons for the superiority of this technique is the fact that the tap-root is not disturbed, let alone cut. At the same time this technique is much cheaper than the routine procedure of nursery-grown seedlings but needs care when evaluating soil moisture and quick action when conditions are appropriate. Such a technique may bring about a revolution in fodder-shrub establishment which at present is much too expensive for small farmers and therefore not sustainable.

Rehabilitation in the Mediterranean arid lands shows that plant material is available that permits virtually all ecological conditions within the Basin to be met. A number of problems, however, constitute a bottleneck for further development: (i) the cost of establishment via the presently available methods of nursery-grown seedlings is far too expensive and not affordable for the small producer, it therefore is not a sustainable proposition in the long term; efforts should be exerted to utilize the new methods that have been perfected abroad such as the direct sowing of pre-germinated seeds or the transplant of bare-root plantlets; and (ii) these new methods, however, such as direct sowing, require large quantities of seeds, it follows that the seed production ought to be organized at the level of each state; in the beginning this cannot be achieved by private enterprise because of the supply and demand ratios, the demand needs to be developed before any private enterprise could embark on such seed production.

Conclusions

Improvement

(i) Provide feed in later summer to early winter when alternative feeds (steppe grazing and cereal stubble) are in shortest supply.

(ii) Wind-breaks to reduce effects of wind and water erosion.

Disadvantages/limits

Too costly to establish fodder shrub reserves (land preparation, purchase of seedlings, initial irrigation) with the classical methods and need to close area for three or four years.

Conditions of use

(i) Take into account the bioclimatic requirements: water stress and cold stress tolerance.

(ii) Direct seeding of pre-germinated seed is the most promising technology for establishment.

(iii) With nitrogen-deficient shrubs, a cheap source of nitrogen must be added in the form of urea and some energy from roughage such as straw, for a maintenance ration.

(iv) The animals should be habituated for a minimum time of three months in order to reach the maximum level of intake.

(v) Multi species rations provide better intake and performance than single species rations.

Recommendations

The seed production is to be organised at the level of each state.

Technology 4: By-product quality improvement

Description of the traditional/conventional technology

Crop residues, especially cereal straw, and agroindustrial residues play an important role in Mediterranean animal production systems, particularly in periods where no other feeding resources are available. Nevertheless, their general poor quality in terms of palatability, fibre content, digestibility, protein, energy, minerals, etc. limit their use and efficacy.

Objective of the alternative technology

The objective of the alternative technologies is to improve the intake and nutritive value of these by-products.

Description of the alternative technology

The following technologies have been tested:

(i) Two technologies to improve the feeding value of cereal straw: treatments with fertiliser-grade urea, and with anhydrous (gaseous) ammonia or ammonium hydroxide solution. Chopped or baled barley and wheat straw is treated with a solution containing about four percent fertiliser-grade urea (46% nitrogen), stacked, covered with plastic sheeting or mud. After three weeks the straw can be offered directly to ruminant livestock. Other methods of treating straw was to use ammonium hydroxide solution which is mixed with the straw, and anhydrous ammonia (as a gas) which is injected into covered stacks.

(ii) Addition of dried poultry manure (DPM) to other ingredients in compound feeds or freshly ensiled with green forages (barley, maize) or agro-industrial waste products such as grape marc and tomato pomace is another technology.

(iii) Addition of urea to rations based on sugar beet pulp silage (BPS) and straw.

(iv) Use of olive by-products (dry leaves, olive cake and ground branches) in compound feeds.

Summary of results – Urea

At research and experimental level

Algeria. Dib (1990-1994, 1998). An experiment has shown that ewes receiving urea treated straw have an ADG 68% higher than animals receiving non treated straw (96 vs 57 g/day) although much lower than animals receiving concentrate and hay (125 g/day).

Syria. Hadjipanayiotou *et al.* (1993c). Lactating Awassi ewes divided into two groups; initial live weight about 59 kg; each day ewes offered 560 g straw treated with anhydrous ammonia received 100 g concentrate, 100 g barley grain, 100 g barley/vetch hay and 100 g whole lentil pods *less* than controls; trial lasted 12 weeks. Ewes with treated straw had a higher daily gain (26 vs 3 g/day) and produced 6% less milk (432 vs 462 g/d) than control ewes.

Syria. Hadjipanayiotou *et al.* (1993c). Awassi ewe lambs divided into two groups; initial live weight about 40 kg; straw treated with urea and offered ad-lib; intake of straw by both groups similar (744 g). Daily loss is 17% lower for ewe lambs with treated straw (73 g/d vs 88 g/d).

Syria. Hadjipanayiotou *et al.* (1993c). Awassi ewes divided into two groups; initial live weight about 40 kg; both groups offered daily 250 g barley grain; daily intake of urea-treated straw 792 g, daily intake of untreated straw 741 g. Ewes with treated straw had 59% higher daily gain (65 vs 41 g/d).

Turkey. Gürbüz *et al.* (1996, 1998). Urea added to rations based on beet pulp silage, straw and concentrate feed may improve growth rates of bulls up to 5.7%, feed conversion up to 6.1% and net benefit up to 13.3%. Although results are worse for growth rate and feed conversion than in a conventional system based on barley and concentrate, net benefit can increase up to 7.3%.

At research and experimental level

Syria. RAB/89/026 Project Annual Report 1991/1992. Awassi ewes divided into two groups; initial live weight about 49 kg; trial lasted 63 days; urea-treated straw replaced untreated straw, 150 g/d commercial concentrate and 150 g/d wheat bran. Ewes with treated straw had 44% more daily gain (52 vs 36 g/d), 26% more milk (580 vs 460 g/d) and 8% less daily gain in lambs (155 vs 168 g/d).

Syria. RAB/89/026 Project Annual Report 1991/1992. Awassi ewes divided into two groups; initial live weight about 47 kg; trial lasted 60 days; urea-treated straw replaced untreated straw, 150 g/d commercial concentrate and 150 g/d wheat bran. Ewes with treated straw had 14% more daily gain (50 vs 44 g/d) and 15% less daily gain in lambs (186 vs 218 g/d).

At farmer level. On-farm surveys

Syria. Thomson *et al.* (2000). The sample of farmers hosted demonstration trials on the technology and many of them also attended field days to see it; results show that two-thirds of farmers in the sample used the technology at least once after hosting an on-farm trial or attending a field day.

Conclusions – Urea

Improvement

Lower live weight losses or better live weight gain; can be cheaper to feed than commonly used supplements; nutritional value of cereal straws often claimed to improve.

Disadvantages

Need special equipment and less safety concerns with gaseous NH_3 and NH_4OH and urea.

Limitations

Can only replace a small part of commonly used feed supplements due to low energy content although additional nitrogen results in enhanced intake.

Conditions of use

(i) Need efficient extension service to promote technology at farm-level.

(ii) Establish that technology suitable for large producers.

Recommendations

(i) Evaluate the opinions of farmers concerning the technology from a socio-economic standpoint and estimate the level of adoption among farmers who had previous hosted on-farm demonstrations and/or attended field days. (Base analysis on current prices of inputs and outputs and labour needs to make treated straw and estimate the economic returns from the technology.)

(ii) The Animal Production Division of the Directorate of Agricultural Scientific Research (DASR) should identify pilot producers with large flocks and advise them on the sources of ingredients, production, pricing and marketing of treated straw.

Summary of results – Poultry manure

At research and experimental level

Syria. Hadjipanayiotou *et al.* (1993a). 81 lactating Shami goats divided in two groups; about 55 kg live weight at start; 330 g DPM/kg concentrate replaced all cottonseed cake and part of the barley grain in control diet; daily concentrate intake of two groups similar; daily straw intake of two groups differed by 40 g; trial lasted 50 days. Daily loss was 41% lower (52 vs 88 g/d) and milk yield was 12% higher in goats receiving DPM.

Syria. Hadjipanayiotou *et al.* (1993a). 286 growing male/female Shami goats divided into 2 groups; about 28 kg live weight at start; trial lasted 125 days; concentrate intake of control group 60 g higher than DPM group; straw intake of two groups similar. Daily gain was 24% lower (19 vs 29 g/d) in goats with DPM in diet (at 330 g DPM/kg).

Syria. Hadjipanayiotou *et al.* (1993b). 104 young female mountain kids divided into two groups; about 33 kg initial live weight; trial lasted 40 days; daily concentrate intakes were 847 (C) vs 525 poultry litter in silage (PLS) g and straw intakes were 346 (C) vs 148 (PLS) g; daily silage intake by PLS group was 560 g fresh matter (FM). Daily gain was 30% higher (86 vs 66 g/d) in kids with PLS in diet.

Syria. Hadjipanayiotou *et al.* (1993b). 133 rams divided into two groups; about 60 kg initial live weight; trial lasted 60 days; daily concentrate intakes (g) were 971 (C) vs 478 (PLS) and straw intakes were 583 (C) vs 382 (PLS); daily silage intake by PLS group was 698 g DM (2181 g FM). Daily gain was 10% lower (103 vs 114 g/d) in rams with PLS in diet.

Syria. Hadjipanayiotou *et al.* (1993b). 46 lactating ewes divided in two groups; about 61 kg initial live weight; trial lasted 49 days; daily concentrate, lentil grain and legume straw intakes (g) were respectively, 1228 (C) vs 956 (PLS), 464 (C) vs 395 (PLS), 240 (C) vs 203 (PLS); intake of silage by PLS group was 334 g DM or 1043 g FM. Ewes receiving PLS in diet had 9% lower daily gain (80 vs 88 g/d) and 6% higher milk yield (583 vs 551 g/d).

Conclusions – Poultry manure

Improvement

Usually increases live weights, live weight gains and milk yield or leaves these parameters unchanged while saving on commonly used supplements.

Disadvantages and limitations

Unless used in carefully controlled conditions, risks to health of animals and humans are present, such as from pathogens and residues from feed additives (growth promoters, antibiotics, coccidiostats, etc.).

Conditions of use

Poultry litter and manure should not be included in feeds for ruminant livestock.

Recommendations

Use of poultry litter and manure in feeds of any kind for ruminant livestock should be prohibited for health, moral and religious reasons.

Summary of results – Use of olive by-products in animal feeding

At research and experimental level

Tunisia. Khorchani *et al.* (1997), Nefzaoui and Zidani (1987) and Nefzaoui (1985). Three by-products of olive tree: dry leaves, olive cake and ground branches have been used. Results show that they are a useful source to satisfy needs of animals in the south of the country, but the disadvantage is its low nutritive value that is insufficient as an exclusive source for productive animals.

At farmer level. On-farm surveys

48 surveys for users and 24 for non users have been carried out in Tunisia. Age is about the same although very high (64 vs 63 years), the level of education is lower for users (37.5 vs 54.2) and the size of the flocks is similar (17 head). The technology is considered easy by farmers and well accepted. The main reasons given for the non use are the high investment needed and the poor quality of products.

Conclusions – Use of olive by-products in animal feeding

Improvement

Useful source to satisfy needs of animals in the south of the country.

Disadvantages

Low nutritive value, insufficient for the productive animals.

Limits

The advisable proportions for each category of animals should not be exceeded.

Conditions of use

To use as a back-up feed resource or to weaken proportion in normal conditions.

Recommendations

To combine with other fodders of better nutritive value if possible.

Technology 5: Feeds

Objectives – Feed blocks (FB)

(i) Improve the nutrition of ewes and does using widely available alternative and non-conventional feed resources, help in saving animals in very drastic situations (feed shortage) and keep them alive, and improve feeding in particular situations as, for example, prior to mating or during lactation.

(ii) Improve forage quality which is usually low (deficient mainly in nitrogen and in minerals) mainly when feed is lacking and valorise by-products that are available locally.

(iii) Reduce feeding costs.

(iv) Improve environment by using wastes from factories.

Implementation – FB

FB are prepared from locally available and preferably cheap ingredients such as urea and cement (as a binding agent) and agricultural (straw, bran) or agro-industrial by-products (molasses, olive by-products). Minerals (both macro- and micro-) and fat-soluble vitamins may be added, and antihelminthics but only if there is a well proven need.

Ingredients used may be diverse. In the results presented below the following formulae have been used:

(i) *Algeria*: F1 = Urea (7%) + molasses (12%) + minerals (4%) + salt (1%) + cement (9%) + wheat bran (24%) + olive stone (32%) + chopped straw (11%); F2 = urea (5%) + minerals (4%) + salt (1%) + cement (9%) + wheat bran (27%) + chopped straw (11%) + olive stone (43%).

(ii) *Morocco*: molasses (40%), wheat bran (30%), urea (10%), mineral complement and vitamins (5%) and cement (15%).

(iii) *Syria/ICARDA*: 30 formulations are reported; density of the blocks varied according to the percentage inclusion of molasses.

Summary of results – FB

At research and experimental level

Algeria. Bouaou (1994). Ewes in stubble. Ewes receiving FB keep weight although with a daily gain 62% (23 g/d) and 77% (14 g/d) lower than control ewes (60.5 g/d) receiving wheat straw and concentrates. Cost of rations with FB is 20% of that of control.

Morocco. Boulanouar *et al.* (1996). Ewes in stubble. Compared to the ewes receiving the classical rations based on straw and concentrates, ewes receiving FB keep weight during pregnancy although with a gain 22% lower (1.5 vs 1.92 kg), have lambs with a weight at lambing 2.1% lower (3.75 vs 3.82 kg) and a daily gain during the suckling period 30% lower (170 vs 242 g/d). The cost of a kg of block is 1.30 Dh (0.125 €).

Syria. Different experiments with animals receiving FB compared to conventional rations. Ram lambs reduce daily loss by 40% (Hadjipanayiotou *et al.*, 1993d), ewe lambs increase daily gains by 63% (Hadjipanayiotou *et al.*, 1993d), ewes and ewe lambs reduce daily loss by 50% (Hadjipanayiotou *et al.*, 1993d), live weight gains increase by 1100% (96 g/d).

On-farm trials

Algeria. Bouaou (1994). Ewes in stubble. Compared to ewes with conventional ration, daily gain (35 g/d) is 62% lower for ewes receiving FB.

Morocco. Chriyâa and Boulanouar (1996). Calves in stubble receiving FB have 66% higher daily gain (288 g/d) than calves without FB.

Morocco. Taghzouti *et al.* (2000). Ewes grazing cereal stubble and supplemented with two types of FB for 8 weeks. Live weight gain is 2.9 to 5.8 kg, with a consumption of 126 and 189 g/d.

Syria. Ewes grazing cereal stubble with FB have 67% (67 g/d; RAB/89/026 Project Annual Report 1990/1991), 186% (86 g/d; Hadjipanayiotou *et al.,* 1993d), 181% (87 g/d; Amin, 1997) and 7% (73 g/d; ICARDA, 2002) higher daily gain; 20% less daily gain (80 g/d; ICARDA, 2002); or reduce by 59% their weight loss (41 g/d; Hadjipanayiotou *et al.,* 1993d) compared to controls without FB. Intake of blocks (ICARDA, 2002) has been 280 and 200 g/d.

At farmer level. On-farm surveys

10 surveys have been carried out in Morocco. Surveyed farmers are 55 years old on average, 80% illiterate and 20% with a primary education level. They own small flocks (65.2 head as average). FB are provided to all types of ewe (ewe lambs, pregnant ewes, ewes rearing lambs, empty ewes, etc.). The investment indicated is 111 €/ha, which is considered high (20%), medium (40%), low (20%) or very low (20%). The use of the technique is considered very easy (10%), easy (70%) or medium (20%). Access to the technology has been made through research (90%) or a private company (30%). In their opinion, the level of adoption is medium (50%).

12 surveys have been carried out for non users. Surveyed farmers are 51 years old on average, 50% illiterate and 42% with a primary school level. The size of flocks is also small (50.3 head). The reasons for abandonment or the non use of the technology are poor yields (100%) and non profitability (100%).

Conclusions – FB

Improvement

(i) Lower live weight losses / better live weight gains.

(ii) Flock kept alive during severe feed shortage.

(iii) Improvement of the weight of lambs at birth.

(iv) Increase of milk production that contributes to the increase of the weight of lambs during the two first months of lactation.

Limitations

(i) The use of the cement can have a negative effect on the health of the animal.

(ii) Apart from in the largest flocks, farm-level production was not appropriate because of problems with supply of ingredients, consistency of product, etc.

(iii) Blocks have to reach a certain hardness to be only licked but not nibbled because urea has a toxicity risk.

(iv) Only blocks made for feeding in winter would include olive cake which becomes available in autumn.

Conditions of use

(i) Blocks are primarily for supplementing breeding stock grazing on cereal stubbles in summer. But they can be fed in winter to pregnant/lactating ewes/does provided the price of the blocks on an equivalent energy and protein basis is less than the price of the commonly used supplements.

(ii) Creation of manufacturing units or users' associations to decrease the manufacturing cost.

(iii) Government should establish standards of quality (density, composition) for blocks and ensure that standards are applied by making random checks on producers.

(iv) Use of poultry litter and manure in feeds of any kind for ruminant livestock should be prohibited for health, moral and religious reasons.

Recommendations

(i) This technique is easy to use and does not require any sophisticated equipment.

(ii) Prepare inventory of non-conventional feed resources by province and district; include amounts, seasonality of supplies and prices, and names, locations and throughput of main suppliers.

(iii) Evaluate the opinions of farmers concerning the technology from a socio-economic standpoint and estimate the level of adoption of the technology among farmers who had previously hosted on-farm demonstrations and/or attended field days. (Base analysis on current prices of inputs and outputs and labour needs to make blocks and estimate the economic returns of feed blocks.)

Final comments

This technique has been very successful in arid zones. It can allow the valorisation of by-products that are available in each zone and the maintenance of animal weights during difficult periods (end of summer and autumn). However, the technique is not always well accepted by the stockbreeders because the product contains cement. Consequently, research activities need to be oriented in the future towards the following aspects:

(i) Substitution of the cement by other binders.

(ii) Diversification of formulae taking into account the nature of the by-products available locally.

(iii) Development of formulae taking into account animal needs at different physiological stages.

Objectives – Complete rations (CR)

The objective of this project is to produce a cheap CR for ewes kept indoors in order to give a solution to the farmers who abandon totally or partially the traditional system based on shepherds who graze ewes in extensive areas.

Implementation – CR

The CR is packed in bales of 300 kg and distributed in feeding racks that have been developed for *ad libitum* CR. These feeding racks have the capacity to store feed for several days and are designed to avoid the selection of the different ingredients of the feed. Intake is regulated by the proportion of long fibre in the diet which produces the satiety feeling by rumen repletion.

The introduction of the new feeding system started in an area with 50,000 sheep, where 55% of the farms have incorporated this technology. These farms have diverse degrees of technology and facilities, thus showing the high versatility of this system. The necessary investment is 6 €/animal.

Summary of results – CR

At research and experimental level

Spain. Oliván *et al.* (2002). It has been estimated that, compared to the average results in the region, the number of lambs sold/ewe/year can be increased by 47% (1.57 vs 1.07) due to the optimisation of the feeding system. This leads to a higher (35%) total income/ewe/year (117.8 vs 87.2 €). The other relevant positive result of the system is the increase by 69% in the number of ewes/Man Power Unit (600 vs 355). On the other hand total feeding costs are 35% higher, both for ewes and lambs due to the higher productivity. The estimated Gross Margin with own labour with this system is 34.4 €/ewe/year.

On-farm surveys

Spain. The user surveys have been conducted among 12 farmers with an average age of 40.8 years and of whom 7.7% are illiterate, 53.8% have primary education level and 38.5% secondary school level. The main difference with non-users is age (46.8). Both users and non-users own big flocks (875 vs 1095 total head). The average investment needed is 4521 € per farm, which can be considered very high (7.7%), high (15.4%), medium (46.2%) or low (30.8%). Technology is in general considered easy to handle.

Poor yields (50%) and quality of products (50%) and high input costs (50%) were the main reasons for farmers that did abandon the technology. For those that have never used it, the high investment needed (57.1%) and the high input costs (28.6%) are the main reasons for non-use.

Technical and economic results obtained at the research level are confirmed to some extent. Fertility and prolificacy of farmers using this technology are higher than non users (1.3 vs 1.2 lambings/ewe/year and 1.4 vs 1.3 lambs/lambing). This leads to 8% more lambs sold/ewe/year (1.3 vs 1.2). Although the variability is very high, the number of ewes/Man Power Unit has not been better in users (455.5 vs 465). Nevertheless, the income/ewe is 22% higher in users (123.7 vs 101.2 €, with 30.5 and 19.7 €, respectively, coming from subsidies) but the feeding costs (47 vs 39.4 €/ewe/year) and total costs (95.2 vs 78.6 €) are also higher. The Gross Margin is 14.3% higher in users (82.1 vs 71.8 €).

Conclusions – CR

Improvement

(i) The feeding rack can be installed easily in most farms due to its versatility and low cost.

(ii) Permits the standardisation of the production system.

(iii) The type of diet *ad libitum* based on long fibre optimises rumination, increasing the digestive efficiency.

(iv) Permits the number of lambs produced to be increased as balanced rations are given.

(v) Contributes to control of lamb diarrhoea, principal cause of mortality and production decrease in early ages.

(vi) Improves the quality of life of the farmer as it saves him from distributing the feed daily.

(vii) Decreases dependence on labour.

(viii) Permits an increase of the flock size, contributing to increase profitability.

Disadvantages

(i) Cost of the feeding rack.

(ii) Increase of the feeding costs.

(iii) Dependence of the feed producing unit

Limits

(i) Need of adapted buildings.

(ii) Need of a feed producing unit well integrated with farmers' requirements.

Conditions of use

(i) A minimum of previous training is needed in the use of the technique.

(ii) As investments are required, a minimum future horizon is necessary on the farm.

Recommendations

(i) This technique can be recommended for Mediterranean rainfed areas where labour is scarce, especially shepherds.

(ii) However, as large investments are required, the technique can be recommended when the amortisation period is long enough to be compensated by the reduction in labour costs.

Technology 6: Control of reproduction in sheep

Description of the traditional/conventional technology

The traditional reproductive system in Mediterranean sheep flocks is continuous mating, keeping the rams with the ewes all year long. The Mediterranean sheep breeds have a seasonal anoestrus, which is less pronounced than in the northern European breeds, but this limits the fertility of the ewes in a period which goes from December-January to June-July. The consequences of this anoestrus in flock continuous mating is that there is an important reduction of lambings from June to November and a peak on December-January. This has consequences on the number of lambings/ewe/year that can be obtained, on the high dispersion of lambings throughout the year and also on the lamb prices because farmers may have difficulties in marketing lambs in high price periods. The effect of the anoestrus is more marked in young ewes with important consequences on the age at the first lambing.

Description of the alternative technology (+ implementation mode)

For the control of reproduction, two major alternatives are used:

(i) The so called "Ram Effect" (RE) which consists of a separation and sudden introduction of males in a flock, induces ovulation and oestrus in non-cyclical ewes. This method can be used to induce reproduction in sheep during non-reproductive periods, mainly in spring, in order to obtain a planned production of lambs during the year.

(ii) The other major alternative is the use of Hormonal Treatments (HT) for oestrus synchronisation and superovulation. It consists of stimulating the activity of cyclical ewes by supplying hormones. It is especially interesting to apply to advance puberty in ewe lambs and to induce reproduction during lactational and seasonal anoestrus periods, increasing, additionally, litter size. These treatments permit sheep reproduction all year round, making it possible to plan the reproduction of the flock. Mating of synchronised ewes can either be natural mating with rams or through Artificial Insemination (AI).

Summary of results – Ram Effect (RE)

At research and experimental level

Algeria. Sexual season of the Ouled Djellal breed shows a progressive increase of the sexual activity from April-May, reaching its maximum between August and November (Benazzouz *et al.,* 1986). Using RE, fertility between 48% (December-January) to 100% (August-September) can be obtained through the year.

Morocco. Sexual season of the Sardi breed shows a progressive increase of the sexual activity from April-May to reach its maximum between August and November (Lahlou-Kassi *et al.,* 1989). Using RE, fertility between 45% (December-January) to 100% (August-September) can be obtained throughout the year (Kabbali and Berger, 1990).

Spain. Alonso (1983). Percentage of cyclical ewes in spring can increase with RE by 250% with respect to non-stimulated ewes (87 vs 33%). Folch *et al.* (1988). Induction of puberty in ewe lambs: the response depends on the season of the year, with 0% of ewe lambs ovulating in deep anoestrus (January) and 71% in May. For post-partum anoestrus, response depends on the interval between lambing and RE: 18% ovulating ewes for RE 5 days after lambing and 49% for RE after 20 days.

Folch *et al.* (1987). Body Condition Score (BCS) and flushing influence results from RE in spring. Fertility is 32%, 67% and 77% respectively for ewes with low, medium and high BCS, and prolificacy 1, 1 and 1.06. Flushing increases fertility to 65% for low BCS and fertility (78%) and prolificacy (1.06) for medium BCS.

Valls Ortiz (1981). The integration of RE within the reproduction management leads to reproduction systems with three matings/year ("three lambings in two years"), five matings/year or, even, with matings each month. Number of lambs/ewe/year can increase up to 23% compared to the traditional continuous mating system (1.78 vs 1.45).

At farmer level. On-farm surveys

This technology is one of the most used among the animal production technologies and this fact has a reflection on the number of on-farm surveys. For users, 15 farmers have been surveyed in Algeria, 6 in Egypt, 6 in Morocco and 13 in Spain. For non users, 15, 4, 9 and 9 have been surveyed respectively in these countries. There are differences between these two groups of farmers in terms of age, the users being younger, and of education level, with a higher level for users. Flocks are bigger in user farmers (61.5 vs 27 in Algeria; 180 vs 129 in Morocco; and 1175 vs 663 in Spain).

RE is practised in different seasons of the year, spring in Algeria, autumn in Egypt, summer in Morocco and all seasons in Spain. Matings last for 30, 36, 92 and 38 days respectively in these countries and the ratio of ewes/ram is 25, 27, 41 and 43, respectively. Rams are always kept in different buildings, at a distance between 3.8 (Morocco) and 1778 m (Spain). Differences in yields between evaluated technology and control have been observed in Algeria and Spain in the number of lambings/ewe/year (91.4 vs 79.8 in Algeria; 1.33 vs 1.19 in Spain), the prolificacy (1.16 vs 1.02 in Algeria; 1.39 vs 1.30 in Spain) and the number of lambs sold/ewe/year (1.32 vs 1.2 in Spain). Regarding economic indexes, this technology allows an important percentage of lambs (58.3) to be sold during the high price period in Spain.

The technology is in general well mastered by farmers, there being the need of a higher number of rams and of keeping them in separate buildings from ewes being the most frequently mentioned difficulties. The opinion on the level of adoption is in general high, with the exception of Morocco.

The main reasons for non use are the high investment needed, the non profitability and the technical difficulties.

Conclusions – RE

Improvement

(i) *Production:* to improve the number of ewes displaying heat, fertility and prolificacy in non-reproductive periods, mainly during the non-breeding season.

(ii) *Organisation:* to plan reproduction in the flock. To make possible 3 lambings in 2 years.

(iii) *Market:* to sell lambs out of season in good price periods.

Disadvantages

Important disadvantages do not exist. Only a minimum of infrastructure is needed (percentage of males; facilities for previous male/female isolation and for lambing concentration)

Limits

(i) We can expect to change results according to the year, breed, flock, and geographic area.

(ii) The effectiveness of the technique depends on factors such as male/female isolation period, stimulus length, body condition percentage of spontaneously cyclical ewes, etc.

Conditions of use

A minimum of previous education is needed to carry out the technique appropriately.

Recommendations

(i) This technique is widely recommended. It is an inexpensive way to control the reproduction of sheep that may or may not be combined with hormonal methods.

(ii) In local breeds of the Mediterranean Basin, most ewes suffer a halt in their regular ovulations in spring, but some of them continue to be cyclical throughout the seasonal anoestrus. The proportion of spontaneously cyclical females in the flock favours out-of-season mating by applying the male effect. Body condition (i.e. long-term nutrition) and flushing of ewes at mating are decisive factors for the response to the male effect. In addition, it is necessary to take care to maintain previous isolation, use a sufficient proportion of males, etc.

(iii) In conclusion, it is necessary to give the farmer adequate information about use and factors of variation of the male effect before they use it.

Summary of results – Hormonal Treatments (HT)

On-farm trials

Folch (1984) shows the effect of experience and training on the results obtained with the same group of farmers using HT in 1976, 1977 and 1979: 55.8, 62.5 and 81.1% fertility; 1.52, 1.49 and 1.96 prolificacy; and 0.85, 0.94 and 1.33 fecundity (number of lambs born/ewe synchronized). Folch (1990), ewes with hormonal treatments produce 21% more lambs than ewes in natural mating.

Carnearagón (1999, unpublished results). Study the technical and economic benefits of the synchronisation of a limited number of the ewes (15%). The number of lambs born/ewe/year increased by 6%, the average lamb price by 3.2% and the total income/ewe by 25% (62.5 vs 49.9 €).

Folch *et al.* (1979). Compare AI vs mating with rams in ewes synchronized with progestagens and PMSG in spring. No significant differences were found.

At farmer level. On-farm surveys

17 surveys for users and 5 for non users have been carried out in Spain for farmers using HT followed by a natural mating with rams. Educational level is higher in users (47 vs 29% have seconday school level). Users' flocks are bigger than non users' (1056 vs 657 head). HT are only used in Spring, with average lots of 42 ewes and 29% of farmers practising hand mating and the rest with group mating. The average period between the previous lambing and HT is 70 days, with a minimum of 57 days. The investment needed for HT is mostly considered low (82%). There are not many differences in production level despite a higher litter size, but the clear advantage of HT is selling lambs in high price periods. The technology is considered as easy by users. The reasons for non use are high input costs (20%), high labour costs (20%) and non profitability (60%).

17 surveys for users and 17 for non users have been carried out in Spain for farmers using HT followed by AI. This technology is used within the framework of a selection scheme in the Rasa Aragonesa breed. The obtained results and the reasons for non use are similar to those obtained with the previous technology.

Conclusions – HT

Improvement

(i) Improvement of fertility and prolificacy in non-reproductive periods.

(ii) Planning of reproduction in the flock.

(iii) Adaptation of sanitary, reproductive and feeding schedules.

(iv) Synchronisation of lambing.

(v) Homogeneous production of lambs at the best time for market.

Disadvantages

(i) This technique requires training.

(ii) Production of non-desirable triplets is possible.

(iii) Infrastructure is needed for hand mating and to control the synchronised lambing.

(iv) Technique is time-consuming.

(v) The use of hormonal products is obligatory.

Limits

(i) Production of non-desirable infrastructure enough to manage concentrated mating as well as concentrated lambing and multiple born lambs.

(ii) Adequate previous education and training of the farmer

(iii) Adequate organised market to sell the produced lambs.

Conditions of use

(i) Infrastructure and training.

(ii) High technical level of the farmer.

(iii) High feeding possibilities.

(iv) Organised market.

Recommendations

(i) This technique should be associated to general improvement of the management of the farm, planning health and feeding of the flock.

(ii) Following the instructions on use of the hormones is highly recommended.

(iii) The number of treated ewes must be decided depending on the number of males existing on the farm. Hand-mating system is highly recommended to mate the treated ewes.

Technology 7: Genetic improvement in sheep and goat

Description of the traditional/conventional technology

Most Mediterranean sheep and goat populations are constituted by local breeds, well adapted to the Mediterranean environmental conditions, and generally with a low production, due in part to a genetic adaptation to the harsh environment and partly due to the shortage of inputs, especially feed. These breeds generally have a low sexual precocity and prolificacy but are characterised by a long sexually active period with seasonal anoestrus which is shorter than in northern European breeds. Growth rate and adult size are also smaller but on the other hand they have a good adaptation to high temperatures and to walking.

Objective of the alternative technology

The objective of the alternative technology is to increase the productivity of the local sheep and goat population while maintaining the adaptation to the local environment.

Description of the alternative technology

The different alternatives analysed for sheep and goat genetic improvement are:

(i) Selection of local sheep breeds.

(ii) Prolific crossbreeding.

(iii) Terminal crossbreeding.

(iv) Multipurpose crossbreeding.

(v) Goat crossbreeding to improve milk production.

Selection of local sheep breeds

Objective: to improve the productivity and economic efficiency of the local breeds without incorporating foreign genes and while maintaining their adaptation to the local environment.

Implementation: selection of local breeds is based: (i) on the election of the best animals of the breed based on their genetic values estimates; and (ii) the maximum diffusion of their genes. For the first step, performance-recording programmes are to be implemented in order to have an objective measure of the selection criteria. Reproduction techniques such as the AI may be used in order to increase the size and to diversify the production environments of the families of some of the individuals (normally males with a good pedigree) to be genetically evaluated. Genetic evaluation technologies pursue to distinguish the part of the performances due to environmental

factors and the part due to the additive genetic value of the animal, BLUP-Animal Model technologies being the most widespread nowadays. Important computing developments are normally used in order to process the data recorded and to estimate the genetic values. For the second step, genes of the selected individuals are diffused giving preference to their offspring as replacement animals, either through natural mating or using more powerful reproduction techniques such as AI.

Prolific crossbreeding

Objective: the objective of this type of crossing is to improve the reproductive efficiency of local Mediterranean breeds.

Implementation: crossbreeding is performed using rams from prolific breeds (Romanov and Dman) in order to produce F1 females that are used as reproducers. Local rams are also to be used in order to produce replacement ewe lambs of the local breed. In many cases, terminal ram breeds are used with F1 females. The creation of a synthetic prolific x local breed is another alternative for the prolific crossbreeding project.

Terminal crossbreeding

Objective: the objective of this type of crossing is to improve growth rate, conversion index and carcass quality of lambs while maintaining the genotype of ewes, characterised by their adaptation to harsh Mediterranean climates.

Implementation: crossbreeding is performed using rams from large size North European breeds with a good conformation. Local rams are also to be used in order to produce replacement ewe lambs.

Multipurpose crossbreeding

Objective: the objective of this crossing was to improve reproduction efficiency, meat production, carcass quality and wool production while maintaining the adaptation to harsh Mediterranean climates.

Implementation: Egypt. The crossbreeding was performed using Merino sheep, MM, of a large size and good conformation with the local Barki, BB, sheep.

Goat crossbreeding for milk production

Objective: the objective of this technology is to improve goat production, especially milk, in oases and irrigated zones in southern arid regions.

Implementation: for twenty years, a crossbreeding project was carried out by the Institut des Régions Arides de Médenine. The exotic breeds used in this project are: Alpine from France, Damascus from Cyprus and Murciana-Granadina from Spain. During the project execution, the performances of growth, milk production, reproduction of kids and goats were recorded for different pure breeds and crossed genotypes. On the basis of this on-station research, this improvement scheme was executed on farms in a number of herds.

Summary of results – Selection of local sheep breeds

Two selection programmes are presented below, the ANOC programme in the Sardi breed of Morocco and the CarneAragón cooperative programme in the Rasa Aragonesa breed in Spain.

In Morocco, there has been no estimation of the selection responses. The average results from the farmers in selection are: fertility 98%, litter weight at birth 4.6 kg, litter weight of the weaning 22.5 kg, ADG 10-30 days 167 g, and ADG 30-70 days 157 g. These results are lower than the control data

results found in the experiment station of INRA Beni, but it can be considered that general environment is more favourable in this station.

The CarneAragón programme in Spain started in 1994 with 48 flocks and 35,000 sheep. Presently in concerns 166 flocks with 105,000 sheep. Selection objectives are fertility and litter size, the last trait being the main selection criterion. Selection programme includes progeny test of rams through AI, with 10,000 AI/year. Selection responses have not been measured, although the estimated response has been an increase of 0.21 lambs/lambing in 10 years of selection. Annual costs are 145,000 € for recording and selection, 24,000 € for hormonal treatments and AI and 24,000 € for data processing, which means a total of 1.83 €/ewe/year. Genetic evaluations are performed by the National Institute for Agricultural Research (INIA) without charge. The costs are partly covered by farmers (0.8 €/ewe/year) and with subsidies (72,000 €/year). Technical feasibility is considered as medium with different types of difficulty, the low response to selection being probably the most relevant. Research has been the main provider of the technology. The level of adoption is rather low, with only 12% of farmers from the cooperative following the selection programme.

Conclusions – Selection of local sheep breeds

Improvement

(i) Litter size.

(ii) Fertility.

(iii) Keep adaptation to the environment.

Disadvantages

(i) Low response to selection.

(ii) High cost for recording and selection.

(iii) High level of organization needed.

Limits

Cooperative selection programmes can only be implemented with groups of farmers who are capable of establishing common and precise goals for genetic improvement and that can commit themselves to programmes that require a great deal of collective discipline.

Summary of results – Prolific crossbreeding

At research and experimental level

The available results in this type of crossing are the crosses between Oulel Djellal and Dman in Algeria and the Rasa Aragonesa and Romanov in Spain.

The F1 Oulel Djellal x Dman shows a prolificacy of 1.6, higher than that of the Ouled Djellal (1-1.15) and lower than the Dman (around 2). ADG is 140 g for F1, 180-220 for Oulel Djellal and 100-120 for Dman.

The F1 Romanov x Aragonesa shows better reproduction indexes than the local breed, with the exception of fertility throughout the year in adult ewes which is 19% lower and the mortality of lambs which can be much higher, up to 113%. Sexual precocity can increase up to 150%, litter size up to 59%, and the number of lambs sold per ewe in her first 5 productive years improve by 53%. There are no relevant differences in the results obtained with the F1 and the synthetic breed.

At farmer level. On-farm surveys

4 user farmers and 18 non users have been surveyed in Spain for synthetic Romanov x Aragonesa. User farmers are younger (40 vs 44 years) and have a higher educational level (75 vs 28% secondary school). The size of flocks is smaller in users (783 vs 1006 head). Females and males are mostly produced in their own flock. Special care is given during the lambing period and multiple birth lambs are partly artificially reared. As expected, prolificacy is the technical index which shows an improvement although somewhat diffused by the fact that only a part of the flock is normally of this genotype. The technology is considered of medium difficulty, the organisation of the flock being the main limit. The main reason for the non use is to be a partner of the programme of production of lambs under the designation of origin "Ternasco de Aragón". These lambs have to be purebred of the Rasa Aragonesa local breed.

Conclusions – Prolific crossbreeding

Improvement

(i) Sexual precocity.

(ii) Litter size.

(iii) Saleable number of lambs.

Disadvantages

(i) Higher incidence of triplets and more.

(ii) Higher lamb mortality.

(iii) More difficult general management (matings, lambings, ewe feeding, ewe replacement, etc.).

(iv) Higher cost of rams.

(v) Need to keep a part of the flock as pure local breed, unless it is possible to purchase F1 females.

(vi) Environmental impact: possible degradation of local populations.

Limits

(i) When lambs of the local breed have a premium price due to a better appreciation by consumers or by quality regulations (designation of origin, etc.).

(ii) When local breed reaches higher litter size (around 1.5).

Conditions of use

(i) To be used when a quick increase of productivity is needed.

(ii) Carefully plan matings and replacements.

(iii) Organise shed with individual adoption pens for ewes lambing triplets and more.

Recommendations

(i) This technique can be recommended when the previous conditions of use can be fulfilled.

(ii) If possible, use terminal rams on F1 and synthetic ewes in order to take advantage of the potential improvement in growth rate and quality of carcasses.

(iii) It is advisable to study locally the market acceptance of the crossbred.

Summary of results – Terminal crossbreeding

At research and experimental level

As a consequence of a better global growth rate, age at slaughter is reduced by between 13 and 17%, and conversion index between 5 and 15%. Carcass quality is also improved, with a reduction in fat percentage up to 22% and an increase in the conformation index of 12%. It is to be noted that the reproductive performance of the rams of terminal crossing breeds is worse than for local breeds with a reduction of 16% in the number of matings in 12 hours.

At farmer level. On-farm surveys

The same 4 user farmers and 18 non users as for the previous technology have been surveyed in Spain. No technical indexes related with this technology could be quantified. Regarding the quality of lambs, crossed lambs are considered of the same quality as the lambs of the local breed. The degree of feasibility is considered as medium, the organisation of the flock being the most limiting factor. The main reason for the non use is to be a partner of the programme of production of lambs under the designation of origin "Ternasco de Aragón". These lambs have to be purebred of the Rasa Aragonesa local breed.

Conclusions – Terminal crossbreeding

Improvement

Growth rate, conversion index and carcass quality.

Disadvantages

(i) Lower reproductive performance of rams.

(ii) Higher cost of rams.

(iii) Environmental impact: possible degradation of local populations.

Limits

When lambs of the local breed have a premium price due to a better appreciation by consumers or by quality regulations (designation of origin, etc.).

Conditions of use

(i) Terminal breed rams should be kept indoors.

(ii) Organise matings separately from local breed rams.

(iii) Use preferably in the periods when no replacement is kept.

Recommendations

(i) This technique can be widely recommended.

(ii) It is advisable to experiment locally (breed, optimum weight, management of rams, etc.) before using it on a large scale.

Summary of results – Multipurpose crossbreeding

Lambing rate and number of lambs weaned were similar in F1 and in the local breed did not change. The conception rate was improved in F1 with respect to the local breed (79 vs 69%) while the lambing, birth, weaning and yearlings were higher in the F1 (3.59 vs 3.41 kg; 20.1 vs 18.7 kg; and 36.0 vs 33.4 kg, respectively) but the number of kg of lamb weaned was lower in the F1 (10.4 vs 11.4). Greasy fleece weight and carcass weight were the only criteria in which the F1 was clearly better (respectively 4.3 vs 3.2 kg: +34.4%; and 44.2 vs 41.5 kg: +6.5%).

Conclusions – Multipurpose crossbreeding

The higher the proportion of Merino blood in the cross the more difficulty for the cross to be adapted to the prevailing desert conditions.

Summary of results – Goat crossbreeding for milk production

Fertility rates did not differ much between the compared genotypes. Litter size was generally higher (up to 42%) in the local breed compared with all foreign genotypes or the F1 crosses. Abortion rate and kid mortality were higher in foreign breeds, especially the Alpine. Weight at birth and at 4 months of age were generally higher in foreign breeds and crosses.

Milk production, the main objective of crossbreeding was much higher in foreign breeds than in the local breed (1.78 kg/day for Alpine, 1.34 for Damaquine, 1.09 for Murciana and 0.79 for local breed). For F1 crosses, the superiority was between 43% (Murciana) and 115% (Damasquine).

Conclusions – Goat crossbreeding for milk production

Improvement

Growth rate, carcass weight, milk production.

Disadvantages

(i) Lower production of exotic breeds compared to their performances in the original countries, due to an environmental x genotype interaction.

(ii) Lower reproductive performance of crossed and exotic breeds.

(iii) Higher mortality rate, especially due to respiratory diseases.

(iv) Cross scheme not easy to be correctly controlled.

Limits

(i) Improvement restricted to oases and intensive systems only.

(ii) Technical knowledge of herds' keepers with a traditional experience with the local goat. Management plan required for high productive genotypes are not satisfied.

(iii) Milk commercialisation and transformation circuit.

Conditions of use

(i) Creation of structures for collecting and manufacturing goat milk.

(ii) Creation of veterinary centres near herds to resolve reproductive problems and to reduce kids' diseases.

(iii) Intensifying animal food production.

Recommendations

The application of this technique requires improving non genetic factors such as animal feeding and reproductive management. Success depends on technical training of herds' keepers for intensive production.

Technology 8: Young camel artificial rearing

Objectives

This technique aims the safeguard of young camels in years of scarcity and the improvement of the camel productivity by the reduction of the interval between births in normal conditions.

Implementation

In case of insufficiency of the maternal milk, the young is separated from its mother at the age of one to two days to receive the reconstituted milk. When the operation aims to improve the mother's productivity, the separation takes place later, at about the age of one week so the young camel can acquire immunity through the colostrum. The reconstituted milk is the same as that used to nurse calves.

Summary of results

At research and experimental level

Tunisia. Live weights of young camels artificially reared are lower during the first three months (-9.4% at 90 days) but the calving intervals can be reduced by 43.5% compared to camels in natural rearing (403.5 vs 714.5 days). The cost in milk replacers, hay and concentrates is between 111 and 125 DT (75 and 86.5 €) while the cost of labour may increase up to 300 DT (203 €).

Conclusions

Improvement

(i) Care of orphan camel calves.

(ii) Improvement of she-camel productivity.

(iii) Improvement of farmer's income.

Disadvantages

The requirements to master the technique.

Limits

(i) More appropriate for males.

(ii) Difficulty in returning the females to the herd.

Conditions of use

Efficient to care for the young orphans, when there is a lack of maternal milk and to reduce the interval between births in normal conditions.

Recommendations

(i) Provide rearing stations near dromedary raising zones.

(ii) If the objective of this operation is the improvement of productivity, programme an early separation of males to facilitate fattening.

(iii) Provide a place for fattening calves after weaning.

Summary and conclusions. Integration of technologies

The above-presented technologies have shown to be useful to eliminate or reduce the influence of the limiting factors of Mediterranean rainfed agriculture animal production systems, factors which are mostly directly or indirectly related to the Mediterranean climate. Some of the technologies have also proven to be useful to produce in a more efficient way, to increase productivity and to provide better quality outputs. Sheep and goat being the most representative species in the Mediterranean, most of the analysed technologies are applicable to their production systems.

The most limiting factors in Mediterranean conditions are those related with animal nutrition and specifically with the availability or quality of feed resources. The correct management of rangelands, through technologies which involve or combine fertilisation, reseeding and grazing management, may lead to substantial quantitative and qualitative improvement in grazing resources. New forage alternatives, including shrubs, can provide forage resources available at any time of the year and especially in the periods where animals have higher nutritional needs. Some feeds, as feed blocks or complete rations, are also good alternatives both from a nutritional and economic point of view to fill gaps or even to design new feeding systems. The utilisation of some agricultural by-products, such as olive leaves, or the improvement of the quality of some of the most widely-available by-products, such as straw, may also improve the response to animal feeding requirements.

Reproductive performances of the local Mediterranean breeds are another important limiting factor to increase technical and economic efficiency: low sexual precocity, seasonal sexual anoestrus and reduced prolificacy being the traits whose improvement may increase this efficiency. Correct reproduction planning and the use of techniques such as the "ram effect" or exogenous hormones have proven to be a way to improve the number of lambings per ewe and the number of lambs per lambing, and also to be able to market lambs in periods where prices are more profitable. Nevertheless, a correct nutritional status of the animals is a *sine qua non* condition for the reproductive success. Hence, reproduction planning must take into account the feed availabilities and utilise, if needed, some of the technologies mentioned in the previous paragraph.

Genetic improvement, through selection or cross-breeding, can be another important tool to improve traits of economic importance such as reproduction traits in sheep, meat production in goats, and growth rate, feed conversion and carcass quality in lambs and kids. The efficient use of genetic improvement techniques requires both reproduction and nutrition planning in order to organise the coexistence of different genotypes in the same flock and to provide adequate feeding for animals with higher nutritional requirements. In that sense, the nutrition and reproduction technologies described before have generally to be used when more productive genotypes are used.

Finally, some of the technologies evaluated have proven to be useful when the availability of labour is one limiting factor for the production system. The use of fences, together with new forage alternatives, and complete low-cost rations specially designed for small ruminants can be very interesting alternatives in these areas where the traditional figure of the shepherd is disappearing.

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