GRASSLAND USE IN EUROPE

A syllabus for young farmers

A. van den Pol-van Dasselaar, L. Bastiaansen-Aantjes,
F. Bogue, M. O'Donovan, C. Huyghe, eds

éditions Quæ

Grassland use in Europe

A syllabus for young farmers

Agnes van den Pol-van Dasselaar, Leanne Bastiaansen-Aantjes,
Fergus Bogue, Michael O'Donovan, Christian Huyghe, eds

Éditions Quæ

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 727368.

Shared Innovation Space for Sustainable Productivity of Grasslands in Europe

Project Acronym: Inno4Grass

Deliverable 5.3. Specific grassland syllabus (D5.3.1) and PowerPoint presentations (D5.3.2) available for young farmers and advisors

Responsible partner: Teagasc (WP Leader) and Aeres (Task Leader)

Other contributors: GLZ, WUR, RHEA, IDELE, APCA, LWK, UGOE, TRAME, AWE, SLU, NLTO, CNR, PULS, WIR, AIA, LRC

Submission date: 28 February 2019

ISBN: 978-2-7592-3145-4
e-ISBN (pdf): 978-2-7592-3146-1
x-ISBN (ePub): 978-2-7592-3147-8

Italy

Claudio Porqueddu, Rita A.M. Melis,
Lorenzo Pascarella and Riccardo Negrini

Introduction

Italy is a peninsula extending far into the Mediterranean Sea. The estimated population is 60.4 million people (data 2017). The population is unevenly distributed. The Po Valley, in northern Italy, and the metropolitan areas of Rome and Naples, in central and southern Italy, are densely populated, while the Alps and Apennines highlands, as well as the island of Sardinia are very sparsely populated. The average population density is 201 inhabitants per square kilometre, a value that is higher than that of most western European countries.

Italy has a surface area of 301,338 km^2. The territory is mostly hilly (42%) with plain areas only covering 23%, mainly in the Po Valley, which is the country's largest plain (44,000 km^2). The rest of the territory is covered by mountain areas (35%). The Alps, along the northern border, and the Apennines, which form the backbone of the entire peninsula and the island of Sicily, are the largest mountainous systems. Italy lies in the temperate zone but there is a strong climate variation between the northern regions bordering the European continent, and the south, surrounded by the Mediterranean Sea, due to the considerable length of the peninsula (1,200 km). Three main biogeographic regions dominate the country:

– the Alpine area, which has a continental mountain climate;
– the continental climate area, mainly represented by the Po Valley, characterised by hot summers and severe winters;
– the Mediterranean region, covering the central and southern Italian regions and the islands of Sicily and Sardinia. The most important climate trait is the concentration of rainfall during the relatively mild winters and its total absence during the hot summers, associated with a large intra- and inter-annual variability.

Italy has a variety of soils as well, originating from several types of parent materials, at different altitudes, under different climate conditions in preceding eras. Dark-brown podzols are very common in the Alps, where rainfall is heavy. In the Apennines, brown podzolic soils predominate, supporting forests, meadows and pastures. Rendzina soils are characteristic of the limestone and magnesium limestone mountain pastures and of many meadows and beech forests of the Apennines. Sparse red-earth soils, rocky soils, clays, dune sands and gravel can be also found.

The agricultural sector and animal husbandry with a focus on ruminants

(Modified from Lombardi *et al*., 2012 and Porqueddu *et al*., 2017)

Italy enjoys an abundance of agricultural resources and its potential productivity is high. It is a world leader in olive oil production and a major exporter of rice, tomatoes, wine, fruit and vegetables. Despite this, its agri-food trade balance is negative, and Italy is a net importer of agricultural raw materials but a net exporter of processed foods (Centro Studi Confagricoltura data, 2018). With regard to the zootechnical sector, meat production is not sufficient for internal demand and meat is imported from other European countries, particularly from Ireland and Germany. Italy is also quite weak in the dairy farming sector and its milk deliveries contribute 8.2% to total European milk deliveries. Italian self-sufficiency in milk is 84.5% (CLAL data, 2017). The total available milk is mainly processed into PDO cheese (Figure IT1) of which Italy is the main European producer. The exports of dairy products concern 29.3% of the national delivered milk, expressed in milk equivalents, equal to 4.7% of the European exports.

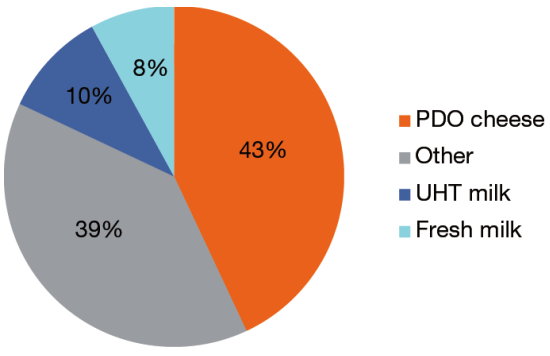

Figure IT1. Destination of total milk available in Italy. National deliveries* + Imported Bulk milk = 13 820 345 tonnes.

* Deliveries buffalo milk, goats milk and sheep milk. % fresh pasteurised milk on National deliveries: 9%. Source: CLAL data, 2017.

Table IT1. Evolution of animal heads per category and milk production in Italy. Eurostat data (2017) and CLAL data (2017).

Animal heads									
Category	**Year**								**2017/2010 (%)**
	2010	*2011*	*2012*	*2013*	*2014*	*2015*	*2016*	*2017*	
Live bovine animals (no. x 1,000)	5,833	6,252	6,252	6,249	6,125	6,156	6,315	6,350	+8.87
Dairy cows	1,746	1,755	2,009	2,075	2,069	2,057	2,060	2,040	+16.84
Buffalos	365	354	349	403	369	374	385	401	+9.77
Beef cattle				2,084	2,014	2,042	2,085	2,123	*+1.87
Live sheep	7,900	7,943	7,016	7,182	7,166	7,149	7,285	7,215	-8.66
Milk ewes	5,416	5,469	5,302	5,247	5,142	5,137	5,206	5,130	-5.29
Live goats	983	960	892	976	937	962	1,026	992	+0.93

Milk production									
Category	*2010*	*2011*	*2012*	*2013*	*2014*	*2015*	*2016*	*2017*	
Raw cow milk from farms (tonnes x 1,000)	11,399	11,298	10,876	10,701	11,037	11,161	11,524	11,950	+7.01
Sheep milk (t)			406,177	383,836	372,526	397,500	424,840	427,430	+5.23
Goat milk (t)			27,940	27,489	28,463	33,200	31,730	37,050	+32.61

Cow milk yield (kg/year)	6.326
Sheep milk yield (kg/year)	172**
Goat milk yield (kg/year)	135***

**Data refer to lactating ewes of the Sarda breed; ***Data refer to goats bred in Sardinia.

The ruminant population consists of 6 million head of cattle, 7 million head of sheep and 1 million head of goats, which represent 7%, 8% and 8% of the total European heads, respectively. Dairy cows prevail among cattle (Italian Holstein and Brown Swiss breeds), followed by dual-purpose milk-beef breeds (e.g. Italian Simmental, Modicana, Tyrolean Grey), and, finally, specialised beef cattle (usually indigenous cattle breeds, e.g. Piemontese, Chianina, Marchigiana, Romagnola). The most important sheep breeds are Sarda and Comisana, specialised in milk production. The number of sheep showed a negative trend over the last seven years (-8.66%), while the number of cattle (+8.9%) and goats (+0.93%) both increased.

Currently, 4.2 million live head of bovine animals and 1.2 million dairy cows (65% and 60% of the national figures, respectively) are raised in the northern regions with intensive systems, where 40% of livestock holdings can be found. Meanwhile, 78% of buffaloes, 72% of sheep and 64% of goats are bred in southern Italy and the main islands (Sardinia accounts for 45% of sheep and 22% of goats).

The number of livestock holdings is about 155,000 (Eurostat, 2016). Their number dropped drastically from 2010 (-65%), and the decrease mainly concerned holdings located in mountain areas of central and southern Italy and small-sized farms. Larger sized holdings (>500 livestock units) showed an increase in number (+9%), indicating a deep restructuring of the livestock system in Italy. The average farm size is 9 ha, but large farms can be found in mountain areas (13 ha), and smaller farms in hilly and lowland areas (8 and 6 ha, respectively). Significant differences between northern and southern regions are also seen in the number of heads per farm: an average of 54 (northern) and 28 (southern) head of cattle are raised per farm. The number of dairy cattle per farm in northern Italy is double that in southern regions (33 vs. 17), while there is one-third the number of small ruminants in northern regions (31 and 14 for sheep and goats, respectively) compared to southern regions (106 and 39).

With regard to the altitudinal distribution of cattle livestock holdings, 74% of them are located in marginal areas (34% in mountain and 40% in hilly areas). However, these holdings account for less than half of the national livestock figures, and there are major differences between northern and central-southern regions that are most likely due to the farming system in place. In fact, in northern Italy, 44% of livestock holdings are concentrated in the Po Valley, where an average of 130 head per farm are raised. The number of heads per farm decreases with altitude: farms in hilly areas raise an average of 35 head of cattle per farm, while the average for farms in mountain areas is just 19. Over the last fifty years, the structure of agricultural holdings has been highly affected by socio-economic changes. A generalised reduction of agricultural surfaces has been observed all over the country, but while the agricultural area declined by 30%, 50% of the surface of permanent grasslands and meadows was lost.

Over the same period, the number of agricultural holdings decreased by 66%. Dairy farms were especially affected by drastic structural changes, with their numbers declining by 80%, while the number of dairy cows declined by only 35%. The heads per farm increased from 8 to 22. The number of sheep and goat farms dropped by 47% and 71%, respectively, while the number of heads of both the species was almost stable. Such changes resulted in an increase in heads per farm.

Grassland types

The utilised agricultural area in Italy is equal to 11.29 million ha, about 40% of the national area (Eurostat, 2017). Grasslands cover about 6.5 million ha.

Table IT2. Evolution of grassland areas in Italy.

Grassland type (ha)	2005	2007	2010	2013
Fodder crops – temporary grasslands	955,380	946,570	1,082,490	1,024,950
Fodder crops – Green maize	215,320	220,380	233,730	274,830
Other green fodder	832,870	849,620	835,360	914,460
Other fodder crops – leguminous plants			103,560	105,510
Fallow land	473,420	494,220	547,720	365,310
Permanent grasslands and meadows	3,346,950	3,451,760	3,434,070	3,316,430

Most grasslands are permanent meadows and pastures (Table IT2), which cover 3.3 million ha (more than 50% of the total grassland area). The southern regions and main islands account for about half of national grassland areas, represented by permanent pastures. In the northern regions, permanent pastures account for 60% of the grassland area, but permanent meadows are widespread due to more favourable soils, land morphology and precipitation distribution.

The majority of permanent meadows and pastures is located in mountain areas (60%), reaching 90% in the Alps and hilly areas (33%). The Apennine Mountains show a lower proportion of permanent meadows and pastures (50%), without differences among northern, central and southern regions. In the lowlands, permanent grasslands are scarcely present and temporary grasslands, represented by annual fodder crops (maize-silage, barley, oat, sorghum, Italian ryegrass, vetch, berseem and crimson clover) and temporary grassland (lucerne, sulla, sainfoin, white clover, red clover, grasses and their mixtures) prevail.

Permanent grasslands underwent a gradual reduction from ‘90s to 2000, when more than 340,000 ha were dismissed, while from 2000 to 2013 their area remained stable (EUROSTAT, 2018). The largest decrease involved pastures and meadows. Currently, permanent grasslands and pastures are widely diffused in the main islands (Sardinia and Sicily, 40.7% of their UAA), followed by the regions of north-western (32.5%), north-eastern (24%), southern (20.6%) and central Italy (18.5%) (ISTAT, 2016).

Grass yield and grass quality

Due to the several bioclimatic areas and soil variability, Italian grasslands show a great variability in terms of production and quality as well as farming systems, where animal breeds, forage resources and level of intensification are adapted to specific environmental conditions. Despite several constraints (i.e. climate, morphology, small size of farms and flocks, lack of technical assistance), Italian grassland production is

rather important, showing interesting and sometimes original models of adaptation to the specific environmental conditions, which are certainly among the most difficult in Europe.

Average annual dry matter yields for grasslands are generally quite low in the rainfed Mediterranean zones, ranging between 1 and 3 t/ha, but can reach up to 10-15 t/ha in the lowlands of northern Italy under continental climate conditions. This high variability in terms of forage production can be divided as follows: marginal lands (nearly 35% of total acreage); intensive agricultural areas (nearly 15%); and intermediate areas between extensive and intensive (about 50%).

Normally in marginal areas there are no temporary grasslands, or if there are, they cover only small surfaces. Grazing is largely dominant, and permanent pastures are the main forage resources outside of woods. Generally in these areas it is possible to find two different systems. In the uplands, utilisation by grazing is limited to short periods during summer with dairy cows in the Alps and with beef cattle, sheep and goats in the upper part of Apennines and the islands. In the more typical Mediterranean areas, there are very long periods of grazing with low stocking rates. The agro-pastoral systems, widespread in interior hilly areas with little mechanisation, are based on diversified resources; semi-natural grasslands and improved pastures coexist in the better areas. Traditionally, wooded grasslands, with up to 10-40% tree and shrub cover, are also used to support livestock production in these regions. These silvopastoral systems are based on woody pastures, but grazing-animal breeding is often associated with other agricultural activities to improve farmers' incomes (e.g. cork production in Sardinia).

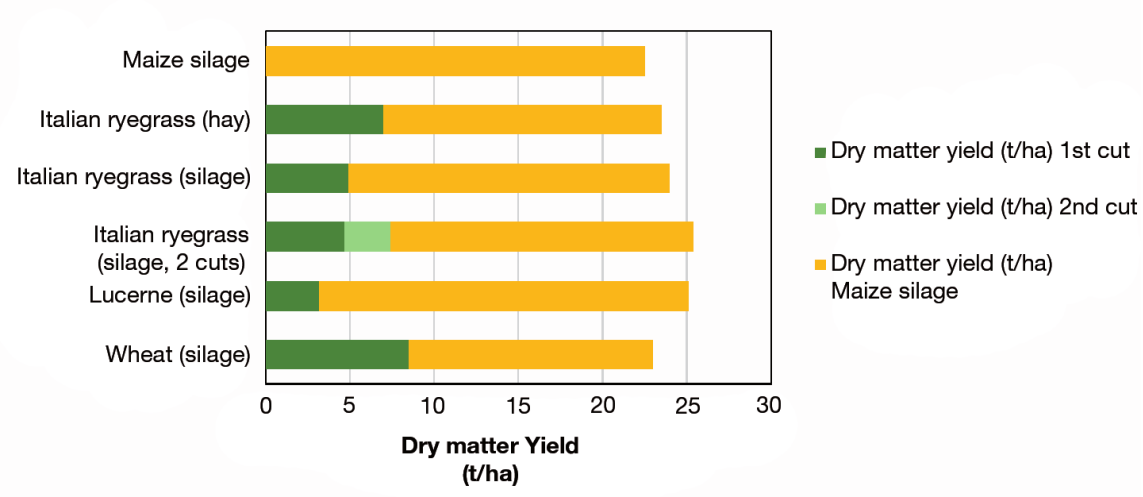

Figure IT2. Double cropping for the intensification of maize for silage systems (Borreani and Tabacco, 2016).

The intensive agricultural areas are where the greater numbers of and most productive animal husbandry systems can be found (e.g. dairy cows in the Po Valley and in other small scattered areas along littorals and Apennine valleys). The common characteristic of these areas is the zero-grazing system with the use of high amounts of supplements. The intensive forage production in the Po Valley is based mainly on maize for silage, which can also enter the forage production systems as a summer crop

(double cropping) following winter cereals (e.g. barley and wheat) or Italian ryegrass as temporary grassland (Figures IT2 and IT3). Maize for silage is supported by rotated meadows of lucerne, Italian ryegrass and ladino clover or cocksfoot, tall fescue with lucerne and ladino clover, or to a lesser extent by permanent meadows. The increase of surface area sown with sorghum confirms the important role that this crop plays in the diversification of farm production. Meadows are widespread in areas where maize cannot be grown due to pedological limitations.

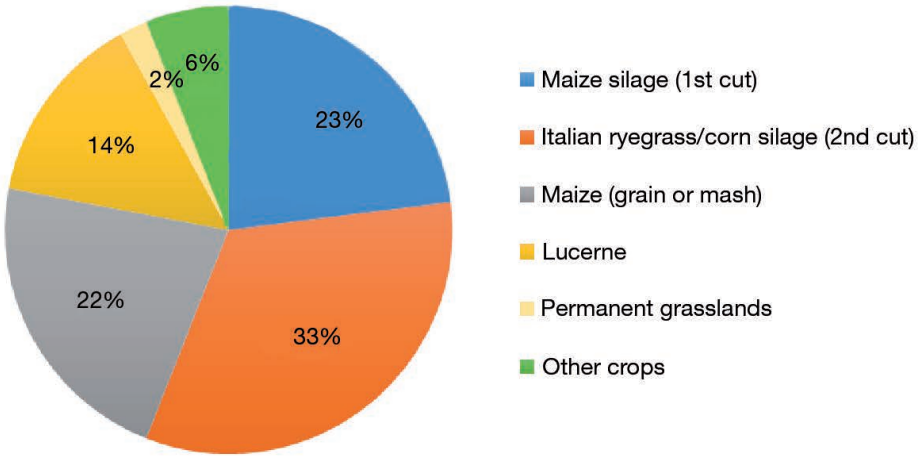

Figure IT3. Recurring forage systems in the Po Valley for dairy husbandry (Borreani and Tabacco, 2016).

The intermediate areas, between marginal and intensive zones, are where temporary and permanent grasslands coexist. They are the most spread out in the low mountains, hilly lands and rainfed plains with mainly beef cattle or dairy sheep. The forage systems are quite variable depending on the farming systems. In the coastal plains and in the dry low hills where mixed crop-livestock systems are present, feeding systems are based on a combination of annual forages and cereal stubble. In hills that can be mechanised, feeding systems based on permanent grasslands and the use of hay storage and pastures are diffused. Production systems vary from those excluding grazing up to the sharp separation of grazed areas and mowed areas, and systems based on use of grazing of the regrowth of grass-legume leys (*prato-pascoli*). The seasonal fluctuation of grassland production requires hay and/or silage reserves in order to deal with difficult periods for feeding animals.

Grassland performances in Mediterranean environments are negatively impacted by several physical constraints, which complicate the mechanisation of soil tillage, and by climate characteristics. In fact, summer drought coupled with high solar radiation levels, cool winter temperatures during the growing season, and highly erratic and variable rainfall all limit grassland productivity. As an adaptation to summer drought, annual species prevail in semi-natural Mediterranean grasslands. Their growing season ranges from four to 10 months, depending on rainfall amounts and timing and plant tolerance to water deficit (300 mm to 1,000 mm), and is characterised by two growing peaks in spring and autumn. Dry matter accumulation ranges between 110 kg/ha/day in the most favourable season (spring) and 20 to 40 kg/ha/day in autumn (Figure IT4, Caredda *et al.*, 1992).

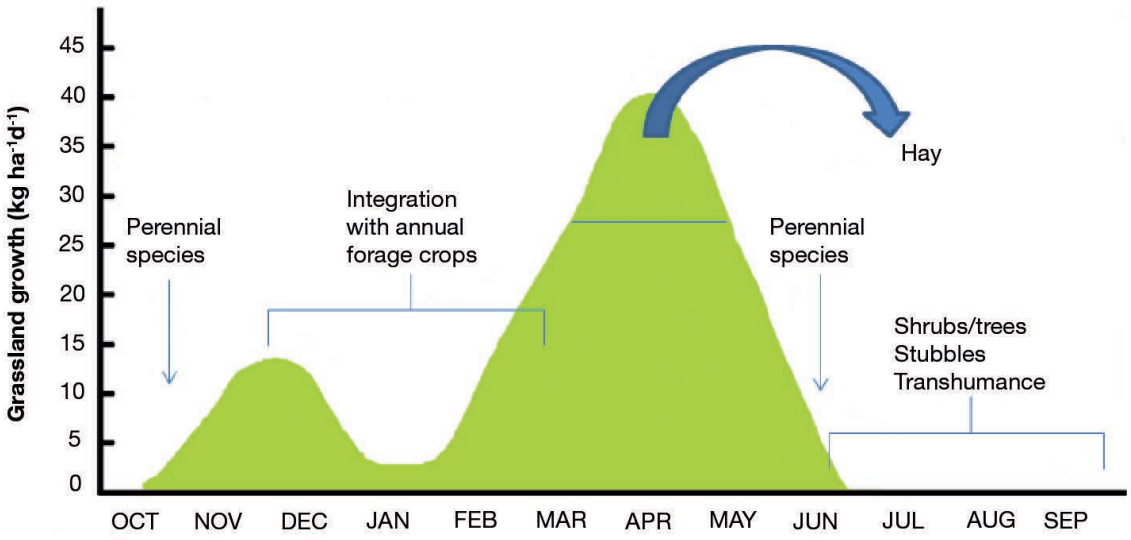

Figure IT4. Herbage production and integrations to grazing animal diets in Mediterranean areas.

Annual and inter-annual forage productions under rainfed conditions are usually extremely variable but generally limited, and depend on grassland management and soil fertility. Typically, average dry matter yields range from 0.5 to 1.0 t/ha/year in semi-natural grasslands, which prevail in marginal soils, to 6.0 to 7.0 t/ha/year, in agriculturally improved grasslands (Table IT3, Huyghe *et al*., 2014). In grasslands subjected to shrub encroachment, herbage production declines with the increasing of shrub cover, as well as its nutritional value (Zarovali *et al*., 2007). In the latter case, an appropriate agronomic or grazing management aimed at controlling shrubs should be introduced to promote grassland renovation and conservation. In semi-natural grasslands, forage is usually low quality, often worsened by a relatively high rate of unpalatable species. A better forage quality can be attained by applying P-fertilisers once a year to boost annual pasture legume production, but when their natural seed bank is not sufficient, the re-sowing with annual self-reseeding pasture legumes is appropriate (Porqueddu and Gonzales, 2006). The most frequently used mixtures include three to four species and are based on subterranean clovers (*Trifolium subterraneum* L. *sensu lato*) and annual medics (*Medicago* species).

To complement the insufficient pasture production in Mediterranean regions, annual temporary grasslands are widely exploited because of their high winter growth rates and flexible use. Traditionally, mixtures of annual forage legumes and winter cereals (oat, barley and triticale) or grasses (especially Italian ryegrass, *Lolium multiflorum* Lam. ssp. *italicum* and ssp. *Westervoldicum*) are used for short-term forage crops on arable lands. The most-used legume species are common vetch (*Vicia sativa* L.), woolly pod vetch (*V. villosa* ssp. *dasycarpa* (Ten). Cav.), Persian clover (*T. resupinatum* L.), crimson clover (*T. incarnatum* L.) and berseem clover (*T. alexandrinum* L.). These temporary grasslands are exclusively cut for hay production or mowed after the winter grazing (one or more grazings per season). Often, farmers harvest forage with a delay which has negative consequences on quality. Recently, farmers have introduced

some mixtures based on annual self-reseeding pasture legumes and winter cereals to extend the duration of temporary grasslands to two or three years. Among perennials, lucerne represents the primary temporary grassland species for neutral and alkaline soils. Quite often the seed of local ecotypes is used in pure stands as green forage, hay or dehydrated forage (three to four cuts between June and October). Lucerne stands typically persist for three to four years under rainfed conditions or occasional irrigation before a rotational crop is grown. Despite their wide-spread natural distribution in hilly areas, perennial legumes such as red clover (*Trifolium pratense* L.) and birdsfoot trefoil (*Lotus corniculatus* L.), which are adapted to moderately acidic soils, have not been widely used. The same is true for sulla (*Sulla coronaria* (L.) Medik.) and sainfoin (*Onobrychis* spp.), although there has been renewed interest in each of these perennial legumes (Porqueddu *et al*., 2016). A few varieties of perennial grasses, particularly cocksfoot (*Dactylis glomerata* L.), tall fescue (*Festuca arundinacea* Schreb.) and bulbous canary grass (*Phalaris aquatica* L.), are sown in higher rainfall areas with deeper soils and are generally included in seed mixtures with annual or perennial legumes.

Table IT3. Grassland dry matter yield (DMY) (t/ha) in six Sardinian sites (average of five years). Fertilisation: 100 kg P_2O_5/ha, 50 + 50 kg N/ha (from Bullitta and Caredda, 1982).

Site	Altitude (m asl)	Type of soil	DMY (t/ha)		DM %	Extension of forage availability (in weeks)
			Unfertilised	Fertilised		
Bonassai	80	Limestone	4.23	8.23	95	+7
Chilivani	350	Alluvial	2.77	5.05	82	+7
Badde Orca	600	Trachitic	3.13	5.52	76	+3
Pattada	650	Granite	4.44	6.33	43	+4
Campeda	650	Basaltic	3.92	6.41	63	+3
S. Antonio	650	Basaltic	2.39	5.38	122	+8

Grazing

In northern Italy, generally, grazing is mainly carried out for a limited period of the year, from two to four months. In central Italy, this phase can easily last up to six months, while in southern Italy and the islands, the mild winters allow year-round open-air grazing. Both continuous and rotational grazing are used, and rationed grazing is also used with limits to grassland access (two to four hours per day). In Table IT4, the suggested values of grass height for entry and exit from the grazing sector in some grasslands used by sheep with rotational grazing are reported. The grazing system can also change during the year in relation to the farm structure, farm grassland resources, grass seasonal growth and animal physiological stage (Table IT5). Hereafter, some of the most common grazing-based farming systems in the country are described.

Table IT4. Suggested values of grass height for entry and exit from the grazing sector in certain grasslands used by sheep with rotational grazing (Molle and Decandia, 2005).

Pasture type	Grass height (cm)	
	Start	**End**
Italian ryegrass	15-20	3-5
Cereals	20-25	8
Lucerne	Start of blooming	3-8
Berseem clover	20-25	8-10
Subterranean clovers and annual medics	10-15	3

Table IT5. Sheep grazing techniques suggested for different grasslands (modified from "Prograze", Molle and Decandia, 2005).

Dry pastures

Prevailing species	Growth phase				
	Stubble (summer)	**Emergence or resprout (autumn)**	**Growth start (winter)**	**Growth end (spring)**	**Beginning of heading/blooming (end of spring)**
Lolium rigidum (self-reseeding)	Moderate grazing to eliminate stubble	Reduce the stocking rate at the emergence of the seedlings to encourage their development up to 3-4 leaves	Continuous or rotational grazing with moderate stocking rate	Continuous or rotational grazing with high stocking rates to delay heading	Avoid intense grazing in order not to reduce re-seeding.
Lolium italicum			Continuous or rotational grazing with moderate stocking rates starting when grass height is 20-30 cm. Avoid grazing if the soil is very humid (compaction)	Continuous or rotational grazing with high stocking rates to delay heading	Continuous or rotational grazing with high stocking rates

Prevailing species	Growth phase				
	Stubble (summer)	**Emergence or resprout (autumn)**	**Growth start (winter)**	**Growth end (spring)**	**Beginning of heading/blooming (end of spring)**
Annual grasslands (oat, barley, triticale) used for grazing	Grazing "hourly" in the presence of grain to avoid acidosis		Rotational grazing with moderate stocking rates when grass height is 20-30 cm (4-6 weeks post emergence). Residual stubble 8-10 cm. Avoid grazing if the soil is very humid (compaction)	Rotational grazing with high stocking rates to delay heading. Stop when grass height is 5-8 cm	Grazing "hourly" in presence of grain to avoid acidosis
Self-reseeding annual legumes (subterranean clovers, *T. michelianum*, annual medics)	Light grazing to eliminate excess stubble, without depleting the seed bank (min 1.5-2 quintals/ha)	Respect the emergence of seedlings up to 3-5 true leaves	Continuous grazing (preferable) or rotational grazing with moderate stocking rates keeping the height in the range 5-15 cm (avoid shading by grasses)	Continuous (preferable) or rotational grazing with high stocking rates to avoid shading by grasses	Avoid grazing or limit its intensity so as not to compromise seeding, especially with the annual medics and clovers
Annual grasslands (*T. alexandrinum, T. incarnatum*) and sulla grasslands	Sulla: light grazing to eliminate excess stubble	Rotational grazing "hourly" (max. 3 hours) with moderate stocking rates starting from an entrance height of 15-20 cm	"Hourly" rotational grazing with moderate stocking rates when grass height is 20-30 cm. Avoid grazing if the soil is very humid. Leave 8-10 cm of stubble	"Hourly" rotational grazing with high stocking rates. Leave at least 6-8 cm of stubble	"Hourly" rotational grazing with moderate stocking rates
Grasslands based on biennial chicory	Light grazing to eliminate the stubble of adventitious grasses	Respect the beginning of the regrowth up to heights of 15-20 cm	"Hourly" rotational grazing with moderate stocking rates starting when grass height is similar to that of first entry. Avoid grazing if the soil is very humid. Leave 5-8 cm of leaf rosette	"Hourly" rotational grazing with high stocking rates. Leave at least 5-6 cm of leaf rosette	Rotational grazing with moderate stocking rates. Leave 5-6 cm of leaf rosette

Grazing systems in the Italian continental regions

In highly productive areas of northern Italy, grazing plays an important role in semi-intensive forage systems under temperate climate (MIPA project, Cavallero *et al*., 1996). Traditionally in the Po Valley, livestock systems are intensive and rely on annual forage crops that offer high yields per hectare to ensure animal dietary requirements are met and allow a high stocking rate. Nonetheless, in some areas, extensive systems and permanent or temporary grasslands are still the basis of animal feeding, especially where annual forage crops show variable yields, i.e. in sandy, shallow, acidic or silty soils.

Meadows are typical for farms in the area of Parmigiano Reggiano PDO cheese production, as this cheese cannot be produced with milk obtained from dairy cows fed with maize silage. The prevalent conservation systems for meadow forage production are haymaking and haylage. In the case of cow-calf line rearing, the choice of the proper stocking rate is the key to increase farm production. Several experiences showed that a stocking rate of max 3.2-3.4 heads/ha offered the best results in terms of animal weight and herbage quality. An example of a traditional calf-cow line rearing is the Piemontese cow rearing. Piemontese cows show very low milk production and their milking is not convenient. This is why cows, after calving, graze in permanent pastures and their milk is used exclusively by their calves. After weaning, herbage availability in pastures is sufficient to assure to heifers an average daily weight gain of 0.7-0.8 kg/day during a grazing season that lasts for 180 to 220 days with no need for feed integration. The cow-calf line rearing is also advantageous because the number of days between births are reduced (386 days vs. 401 with animals in barns) and the first heat is anticipated (14 vs. 17 months). Other advantages are the reduced workload for farmers (-48%) and a lower use of mechanical means.

The main drawback in these systems to a yearly grazing is the marked seasonality of herbage growth, which is also true in irrigated plains. At the same stocking rate, grassland surfaces needed for grazing increase from 25% to 30% in spring to 100% in late summer.

Some data obtained with temporary grasslands showed the important role of grassland management on the behaviour of forage species. A comparison between binary mixtures based on *Trifolium repens* showed that, in association with *Dactylis glomerata,* the sustainable stocking rate under rotational grazing was higher (+3%) than with *Lolium perenne*, all other factors being equal. However, under intensive continuous grazing, the sustainable stocking rate was higher in mixture with *L. perenne* (+5%). The botanical composition of both mixtures based on *T. repens* varied year after year, because this species tended to increase its relative presence in exclusively grazed and/or in mowed areas. To maintain a balanced mixture, the vigour of the selected cultivar of *T. repens* should be accurately chosen, as well as the nitrogen fertilisation planned in spring.

Other successful mixtures are those based on *Festuca arundinacea*. This species shows a high DM yield, high potential stocking rate, high tolerance to animal trampling and easy haymaking. Unfortunately, the presence of animal dejections on this grass reduced the amount of grazed herbage, especially in the case of continuous grazing

(rejected herbage about 30%) compared to rotational grazing (rejected herbage about 20%). The presence of old rejected herbage requires its cut to rejuvenate pastures at the end of each grazing season.

Grazing systems in Italian Mediterranean regions

Beef cattle farming system

In extensive breeding, wild resources such as pastures and permanent grasslands are mainly used and complemented with cultivated forage crops (autumn/winter cereal-based temporary grasslands) to fill the gaps that occur during part of the year (Pardini and Rossini, 1996). An example of extensive breeding can be found in the cow-calf line rearing used with the Maremmana cow breed. This breed is rustic and frugal, resistant to diseases and harsh environments and is able to use poor fodder. A stocking rate of 1.3 LSU is used in the most favourable production conditions. Grazing management is intensive continuous grazing. The farming system is planned for the exclusion of animals from grazing on a portion of the farm only during spring season, when forage stocks need to be created (e.g. 1 April to 15-30 June). A part of forage stocks is used as standing hay for deferred grazing in summer. The remaining portion of stocks are mowed at the end of May and the hay is used to fill the late autumn and winter forage gaps. This farming system allows animal dietary requirements to be met year round and requires limited supplies of forage stocks produced on farm from pastures or temporary grasslands. However, in difficult years, when spring forage production is low, the use of extra farm stocks may be needed. In some forage systems, a portion of the natural pasture is replaced by a pure stand meadow of lucerne or a pasture-meadow based on mixtures of perennial grasses (*F. arundinacea* and *D. glomerata*) and legumes (*T. pratense* and *T. repens*).

Dairy sheep farming systems

Two main farming systems are commonly adopted with sheep. The first is the agro-silvo-pastoral system based on wooded grasslands, which are widespread in hilly and mountain areas. The second one is a mixed cereal-animal system, connected to extensive widespread agriculture in the lowland areas and low hilly areas. Nevertheless, a wide range of intermediate situations exists between these two systems, which gives rise to extremely different and complex variations. In practice, each farm is characterised by its own forage system where the grasslands play a different role.

The agro-silvo-pastoral system is mainly based on the use of natural or semi-natural pastures and sowed pastures with or without fertilisation, and a variable proportion of autumn-winter temporary grasslands. The main limitation of this system is the difficulty to match the forage availability from the pastures with animal requirements. In fact, while grass production is concentrated in spring, the highest sheep feed needs are reached in autumn and in winter at the end of pregnancy and the start of lactation. Moreover, the forage productivity of this system is very unpredictable in quantitative and qualitative terms.

Feed integration is used during these two critical periods. At the beginning of autumn, when the first rains occur, the flock is confined to a small plot to allow the re-establishment of pastures, as well as during winter, when the available forage production in pastures is poor. Usually, a relatively high seasonal stocking rate (10 to 20 sheep/ha) is used, especially if there is the need to reserve areas for mowing or standing hay. Sheep are moved to a new plot (pasture or temporary grassland) on the basis of sward production, but more often on the basis of flock milk production: when it starts to decrease, the flock is moved. Pasture grazing covers between 60% and 85% of the total animal requirements.

In the mixed cereal-animal farming system, winter cereals and temporary grasslands, in pure stand or in mixture with annual legumes, represent the main source while the contribution of pasture is restricted to the areas that cannot be mechanised. They are grazed both as green forage and as stubble. In this system type, crop rotation is based on an irregular sequence (from 2 to 4 years) of different cereal crops, such as durum wheat, barley and oat, and fallow pasture. Cereal crops are largely used because they increase the flexibility of this system, which is well suited to the variable Mediterranean climate conditions. In years with adverse meteorological conditions, cereals are only used for grazing and not for haymaking or grain production. In more favourable years, cereals (especially local ecotypes of barley and oat) can provide high-quality DM biomass for grazing during winter (tillering stage) and once grazing is suspended, usually in mid-February, they are used for grain production.

In spring, the flock is confined to a portion of cultivated lands and pastures, where the high grazing pressure is sustained by the rapid spring growth rates of grass. The remaining arable land is used to produce grain and/or hay. One of the main limitations of the mixed cereal-animal farming system is represented by the establishment of cereals, which is strongly conditioned by autumn rainfall as it can cause long delays due to a prolonged summer drought or, on the contrary, waterlogging. The concentration of production, linked to the typical Mediterranean conditions, makes it difficult to identify simplified solutions and requires a wider diversification of forage system resources. The integration of several fodder sources is essential to achieve satisfactory food quality and make the farming system more efficient, flexible and self-sufficient. In this regard, encouraging results have been obtained with the introduction of the annual self-reseeding pasture species and the perennial species for meadow-pasture, which is discussed in the following section.

⏩ Final remarks on the key aspects for climate change adaptation in Italian Mediterranean grasslands

Several negative effects due to climate change are expected in Mediterranean grasslands: increased failures at establishment, decreased grassland productivity and long-term persistence, shortening of the grazing season unless the grassland is irrigated. Reductions in desirable grassland species is likely in favour of species with low palatability and broad ecological niches, due to reduced competition for water and nutrients (Del Prado *et al*., 2014). In any case, to prevent these possible negative effects,

increasing grassland resilience, improving forage production and rehabilitating permanent grasslands are compulsory. The main factors that can increase resilience and adaptability and which could be considered also as mitigation strategies from climate change are listed below:

- *Sowing annual and perennial species with high summer drought survival.* The predicted changes in rainfall distribution, consisting of relatively lower and more variable autumn rainfall and a shorter spring, mean that some or all of the following traits are needed in annual legumes: (i) earlier maturity for reliable seed set in shorter growing seasons; (ii) more delayed softening of hard seeds to reduce seedling losses from more prevalent false breaks; (iii) greater hardseededness to support grassland survival due to more frequent seasons of little or no seed set; and (iv) a less determinate flowering habit to take advantage of longer growing seasons when they occur. In perennial species, desired characteristics include dormancy or low growth during the drought period, survival across drought periods, and high water use efficiency during the growing season.

- *Increasing legume utilisation.* The biological N-fixing activity of legumes contribute to the soil N-enrichment, and this feature could contribute to farm sustainability. Several species have a different efficiency in fixing atmospheric nitrogen, e.g. up to 150 to 190 kg N/ha/year in sulla and lucerne. In the past, the traditional annual legumes used for grassland rehabilitation were *Trifolium* spp. and *Medicago* spp. Nowadays, other species belonging to the genera *Ornithopus*, *Vicia*, *Melilotus* and *Biserrula* are available on the seed market. Among perennial legumes, lucerne is the most appreciated species in many farming systems but some limitations to its use arise under rainfed conditions, where it shows low forage production, limited persistence and poor tolerance to grazing, requiring the selection of suitable cultivars. Other perennial legumes such as sulla and sainfoin are summer-dormant and already used for both their contribution in stabilising grassland production and forage quality and for their content of condensed tannins, which can promote amino-acid absorption in the intestine as well as reduce the load of gastro-intestinal parasites.

- *Promoting the use of grassland mixtures.* The potential agronomic, environmental and economic advantages of sowing mixtures of forage species and cultivars are widely recognised, especially when mixtures are based on well adapted genotypes. Porqueddu and Maltoni (2007) and Maltoni *et al*. (2007) showed that grass-legume mixtures belonging to different functional groups, achieved higher DM yields, better seasonal forage distribution, better weed control and higher forage quality than pure stands of each species. More persistent grasslands could be also obtained using mixtures of summer-dormant and summer-active perennial species and varieties able to exploit available soil moisture throughout the year (Norton *et al*., 2012).

- *Benchmarking grassland typologies to improve the management of grassland resources.* Knowledge of grassland typology is needed to adopt the best management practices; in fact, the differences in vegetation and phytosociological associations are still relevant in Mediterranean areas. Agronomic typologies based on the forage value of dominant or reference species, or synthetic indexes were designed in different countries, and recently a first attempt to synthesise and homogenise grassland typologies at plot, farm and regional level in the different EU states was made by Peeters (2015). With regards to grazing, the extent and intensity of grazing differs among vegetation

types and geographical locations. Among methods used by technicians and extension services for grassland typology assessment, the pasture-type approach, based on the determination of the pastoral value of grasslands, has been applied in several Mediterranean, Alpine and Apennine areas, with the main goal of characterising pasture vegetation and its potential carrying capacity (Argenti and Lombardi, 2012).

References

Argenti G., Lombardi G., 2012. The pasture-type approach for mountain pasture description and management. *Italian Journal of Agronomy,* 7, 39.

Bonifazzi B., Da Ronch F., Susan F., Ziliotto U., 2008. Effects of cutting management on the floristic composition of two permanent Italian ryegrass meadows. *Grassland Science in Europe,* 13, 221-223.

Borreani, Tabacco, 2016. Sistemi foraggeri per l'azienda zootecnica da latte in Pianura Padana: gestione agronomica e costi Available at: http://www.apapd.it/texts/crown2015/Relazione-BORREANI.pdf

Bullitta P., Caredda S., 1982. Influenza degli andamenti climatici sulla reattività del pascolo alla concimazione. *Ann. Fac. Agr. Studi Sa'isarcsi*, XXIX, 131-140.

Caredda S., Porqueddu C., Roggero P.P., Sanna A., Casu S., 1992. Feed resources and feed requirements in the sheep agro-pastoral system of Sardinia. *Proceedings of the IV International Rangeland Congress*, Montpellier, 22-26 April 1991, pp. 734-737.

Cavallero A., Bassignana M., Iuliano G., Reyneri A., 1996. Sistemi foraggeri semi-intensivi e pastorali per l'Italia settentrionale: analisi di risultanze sperimentali e dello stato attuale dell'alpicoltura. In: Attualità e prospettive della foraggicoltura da prato e da pascolo, 221-249.

CLAL. Statistical data. https://www.clal.it/

Del Prado A., Van Den Pol-Van Dasselaar A., Chadwick D., Misselbrook T., Sandars D., Audsley E., Mosquera- EUROSTAT. Statistical data available at: https://ec.europa.eu/eurostat/web/agriculture/data/database

Losada M.R., 2014. Synergies between mitigation and adaptation to climate change in grassland-based farming systems. *Grassland Science in Europe* 19, 61-74.

Huyghe C., De Vliegher A., Van Gils B., Peeters A., 2014. *Grasslands and herbivore production in Europe and effects of common policies*. Editions Quae, Versailles (France).

Lombardi G., Lonati M., Cugno D., 2012. National case studies: Italy. In: Huyghe C., De Vliegher A., van Gils B and Peeters A. (eds.) *Grasslands and herbivore production in Europe and effects of common policies*. Editions Quae, Versailles (France), 178-179.

Maltoni S., Molle G., Porqueddu C., Connolly J., Brophy C., Decandia M., 2007. The potential feeding value of grass-legume mixtures in dry Mediterranean conditions. In: Helgadottir A. and Pötsch E. (eds.). Final Meeting of *COST Action 852*, Raumberg-Gumpenstein (Austria) 30 August – 3 September 2006, 149-152.

Molle G., Decandia M., 2005. Buone pratiche di pascolamento delle greggi di pecore e capre. Available at: http://www.ara.sardegna.it/system/files/documenti/Buone%20pratiche%20di%20pascolamento%20delle%20greggi%20di%20pecore%20e%20capre.pdf

Norton M.R., Lelièvre F., Volaire F., 2012. Summer dormancy in *Phalaris aquatica* L., the influence of season of sowing and summer moisture regime on two contrasting cultivars. *Journal of Agronomy and Crop Science,* 198 (1), 1-13.

Pardini A., Rossini F., 1996. Sistemi pascolivi nell'Italia centro-meridionale. In: *Attualità e prospettive della foraggicoltura da prato e da pascolo*, 251-267.

Peeters A., 2015. Synthesis of systems of European grassland typologies at plot, farm and region levels. *Grassland Science in Europe,* 20, 116-118.

Porqueddu C., Gonzalez F., 2006. Role and potential of annual pasture legumes in Mediterranean farming systems. *Grassland Science in Europe,* 11, 221–231.

Porqueddu C., Maltoni S., 2007. Biomass production and unsown species control in rainfed grass-legume mixtures in a Mediterranean environment. In: Helgadottir A. and Pötsch E. (eds). *Proceedings of the COST 852 final meeting*, 30 August-3 September 2006, Raumberg-Gumpenstein, Austria, 41-44.

Porqueddu C., Ates S., Louhaichi M., Kyriazopoulos A.P., Moreno G., del Pozo A., Ovalle C., Ewing M.A., Nichols P.G.H., 2016. Grasslands in 'Old World' and 'New World' Mediterranean-climate zones: Past trends, current status and future research priorities. *Grass and Forage Science,* 71, 1-35.

Porqueddu C., Melis R.A.M., Franca A., Sanna F., Hadjigeorgiou I., Casasús I., 2017. The role of grasslands in the less favoured areas of Mediterranean Europe. *Grassland Science in Europe*, 22, 3-21.

Volaire F., Barkaoui K., Norton M., 2013. Designing resilient and sustainable grassland for a drier future: adaptive strategies, functional traits and biotic interactions. *European Journal of Agronomy* 52, 81-89.

Zarovali M.P., Yiakoulaki M.D., Papanastasis V.P., 2007. Effects of shrub encroachment on herbage production and nutritive value in semi-arid Mediterranean grasslands. *Grass and Forage Science*, 62 (3), 355-363.

Layout: Graph’M, France