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Effect of Location, Year and Variety on Winter Cereal Forage Yield and Quality in the Southern Plateau of the Spain

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ABSTRACT : The objective of this research was to study the production and quality of forage at three different times of the year (April, June and July) of six winter cereals in the southern plateau of the Iberian Peninsula. The cereals studied were Triticale (x*Triticosecale wittm)* cv. "Tritano", Oat (*Avena sativa* L.) cv. "Previsión" and cv. "Saia; Rye (*Secale cereale* L.) cv. "Gigantón", Barley (*Hordeum vulgare* L.) cv. "Cameo" and cv. "Albacete". The study was carried out in three different locations and over three successive years of harvesting. The three variables considered were location, year and cereal. The % dry matter (DM), % crude protein (CP), % acid detergent fiber (ADF), % neutral detergent fiber (NDF) and % ash content were determined for the three sampling periods and the quality was calculated in milk forage units (MFU/kg DM), the production in kg DM/ha, MFU/ha and kg CP/ha. In all three sampling periods the quality of the cereals was significantly influenced only by the year and by species. However, for production of dry matter (kg DM/ha), milk forage units (MFU/ha) and gross protein (kg CP/ha) all three variables were of significant influence as were their interactions. In the April sampling, the species which showed a significantly higher production ($p\leq0.05$) was rye (1,693 kg DM/ha), which, along with its forage quality (16.56% CP, 0.886 MFU/kg DM) meant that the same occurred in MFU/ha and kg CP/ha. Significant differences between species were also found for the June sampling. The most productive cereal was again rye with 2,656 kg DM/ha, although its sharp fall in forage quality meant that barley cv Albacete (2,513 kg DM/ha) returned the highest production in forage units (1,934 vs. 1,951 MFU/ha) and barley cv. Cameo (2,413 kg DM/ha) in gross protein production (242 vs. 264 kg CP/ha). The significantly highest cereal production for July was barley cv. Albacete (4,923 kg DM/ha, 9.11% CP 0.722 MFU/kg DM). As a consequence of the results, we conclude that from the viewpoint of nutritional quality and production, rye is the most suitable for use in early spring in whatever year and location. However, barley cv. "Albacete" is the most appropriate for utilisation in later spring or early summer. (**Key Words :** Forage Production, Forage Quality, Winter Cereal, Oat, Rye, Barley, Triticale)

INTRODUCTION

The southern plateau of the Iberian Peninsula in Spain lies at an average height of 500 meters above sea level, and has a typical semi-arid Mediterranean climate. Rainfall is low (300-500 mm/year) and of a highly irregular distribution over the year, with autumn and spring being the wettest periods. The overall annual temperature stands between 14 and 15°C while the majority of soils are from calcareous rock of sedimentary origin.

Sheep farming is common in the area (3.4×10^6 head according to MAPA 2004) as a subsidiary activity to agriculture. Flamant and Casu (1978), among others define it as a Mediterranean system based on complementary binomial cereal-sheep system. The main forage resources are natural pasture, shrublands, fallowlands and stubblelands. The climatic conditions that these resources are available for only short periods and are of low quality (Caballero, 2001). In general, the most critical period for food for these animals is spring and early summer since these agree in the majority of cases with the end of the gestation period and with suckling and so the flocks depend almost exclusively on trough foods. The lack of resources is further aggravated by crops being abandoned because of low harvests, which means that the flocks do not have access to these by-products. Different authors stated that one way of complementing the scarcity of natural pastures or the lack of sub-products would be to cultivate traditional cereals of the area under dry conditions, that can be grazed. These cereals could be barley, oats (Joy and Delgado, 1989; Francia et al., 2006), or rye (Gomez and Tarraga, 1991;

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Table 1. Field characteristics and culture practices at three locations and three years

Location	Year	Date of sowing	Date of sampling		
			First	Second	Third
AGNU	1	06 October	21 April	09 June	13 July
	2	13 October	20 April	11 June	06 July
	3	10 October	18 April	09 June	07 July
CHIN	1	07 October	22 April	11 June	14 July
	2	14 October	21 April	10 June	07 July
	3	11 October	21 April	07 June	08 July
BONE	1	08 October	23 April	12 June	15 July
	2	15 October	19 April	09 June	09 July
	3	13 October	22 April	08 June	12 July

AGNU = Aguas Nuevas; CHIN = Chinchilla and BONE = Bonete.

Ciria et al., 1996).

Worldwide, there are a number of studies on the forage quality of cereals but mainly they deal with grain yield and occasionally with hay (Han and Kim, 1996), silo yield and quality (Kim et al., 2001a and b with rye, Shaoa et al., 2005 vith oats and Zahiroddini et al., 2006 with barley, Mahanta and Pachauri, 2005 with sorghum) in wetter conditions (Mengel, 2005) or under irrigation (Moret et al., 2007). Our study was focused on determining the potential of various winter cereals in different locations, in different years and at different periods: early spring, later spring and early summer.

MATERIALS AND METHODS

The study was carried out at three locations in the south-east of Castilla la Mancha: Aguas Nuevas (Acronymus AGNU) 1°55'07"W., 38°57'33" N., 704 m.a.s.l.; Chinchilla (Acronymus CHIN) 1°20'21" W, 38°52'21N, 986 m.a.s.l. and Bonete (Acronymus BONE) 1°43'28"W, 38°55'32"N, 889 m.a.s.l.; over the periods 1992-1993, 1993-1994 and 1994-1995. According to the Soil Survey Staff (2003) the soils are of types Calcic Petrocalcids, Xeric Hapalargids, and Xeric Petrocalcids, respectively.

The experimental design was a randomized complete block in a split-split arrangement with four replications. Main plots consisted of three locations: Aguas Nuevas, Chinchilla and Bonete, subplots consisted of three years: year 1, 1992-1993; year 2, 1993-1994 and year 3, 1994-1995, and subsubplots consisted of six winter cereals: Triticale (x*Triticosecale wittm)* cv. "Tritano" (Acronymus.Trit); Oat (*Avena sativa* L.) cv. "Previsión" (Acronymus OatP) and cv. "Saia" (Acronymus OatS); Rye (*Secale cereale* L.) cv. "Gigantón" (Acronymus Rye); Barley: (*Hordeum vulgare* L.) cv. "Cameo" (Acronymus BarC) and cv. "Albacete" (Acronymus BarA).

Sowing was performed using a precision seeder in dry conditions in experimental units measuring 1.2×16 m. Doses were 150 kg/ha of seed with one fertilization of 20, 41 and 20 kg/ha of N, P and K, respectively. Dates of sowing and sampling are given in Table 1. Sampling was carried out in experimental units by measuring four times with a 25×25 cm metal square and cutting at a height of 2 cm. A 1 kg sub-sample was randomly taken for analysis from each of the sample. The samples were dried at 60°C for 72 h in a forced-air oven to determine the dry matter content. Samples were then ground, homogenized and passed through a 1 mm sieve.

The analyses performed were as follows: the ash content, following incineration at 550°C, crude protein content, using the Kjeldahl method (CP) (A.O.A.C. method 1990). Acid detergent fiber (ADF) and neutral detergent fiber (NDF), were determined by the methods of Goering and Van Soest (1970). Net energy was calculated (in milk feed units MFU) using the INRA method (1988) where the values for the digestibility coefficients were those given for similar phenological conditions in INRA (1988) and Option Méditerranéenes (1990).

Data were treated using the analysis of variance procedure (ANOVA) through the computer program SPSS^{+} for Windows Realse 12.0 (2003). When significant differences were found, the Least Significant Difference (LSD) test was used for $p \leq 0.05$ to separate the means of the location, year and cereal variables (Steel and Torrie, 1980). For every sampling periods the considered fixed factors were: location, year and winter cereal.

RESULTS AND DISCUSSION

Precipitations and temperatures for the years under study are given in Table 2. Cumulattive precipitations over 25 years are very similar for Chinchilla and Bonete and higher (about 14 mm) than those of Aguas Nuevas. Accumulated precipitation during the first year is close to the mean in the three localities while those for the second and third years are 100 mm lower than the average. Mean temperatures over 25 years are very similar for the three locations (13.6, 13.5 and 13.6°C respectively). Average temperatures for the first year in the three locations are similar to those for the 25 year series, while for the second and third years they are higher.

Table 3 shows the significance of the variables, location, year and winter cereal and their interactions on the quality and production parameters. None of the three sampling periods showed significant differences between the three locations for the qualitative components (CP, ADF, NDF and MFU). Though, there were significant influence according to the location for productive parameters (kg DM/ha, MFU/ha and kg CP/ha). For this reason, the mean values for the three locations are shown in Table 4. Nevertheless, others authors have reported significant

Table 2. Mean air temperature and precipitation at three locations

Location	Month	Rainfall (mm)					Temperatures (°C)			
		Year 1 '92-'93	Year 2 '93-'94	Year 3 '94-'95	25-year mean		Year 1 '92-'93	Year 2 '93-'94	Year 3 '94-'95	25-year mean
AGNU	September	25.1	49.6	37.5	32.1		21.1	18.7	18.9	19.9
	October	63.9	63.4	80.9	42.2		12.9	12.0	15.3	13.8
	November	1.2	39.8	25.8	34.2		10.3	8.7	11.2	8.8
	December	20.4	1.9	1.3	28.8		6.6	6.8	6.8	5.9
	January	0.0	8.8	6.6	21.1		4.8	5.8	5.7	4.8
	February	88.8	25.3	6.1	24.5		6.2	7.7	8.2	6.6
	March	32.0	0.5	1.9	28.9		9.5	12.1	9.4	9.0
	April	16.6	61.8	6.7	48.0		11.3	11.3	12.1	11.1
	May	31.2	26.3	1.3	48.2		14.9	17.9	17.9	15.3
	June	51.5	3.3	39.7	36.1		20.6	22.1	20.5	20.3
	July	3.7	0.4	27.4	12.4		24.1	27.6	25.1	24.3
	August	25.8	0.8	54.2	14.0		24.4	26.6	24.4	24.0
	Sum	360.2	281.9	289.4	370.5	Mean	13.9	14.8	14.6	13.6
CHIN	September	21.3	29.6	30.3	27.1		21.5	18.7	19.8	20.0
	October	75.0	66.1	78.5	48.3		12.8	11.4	14.9	14.1
	November	5.8	37.2	26.6	31.2		10.0	8.1	10.9	8.6
	December	23.7	7.7	6.7	32.4		6.3	5.7	6.6	5.3
	January	6.5	17.7	10.6	28.5		4.4	5.1	5.4	5.0
	February	59.8	26.9	12.1	27.9		5.2	7.1	8.2	6.3
	March	41.1	4.2	8.8	33.6		9.4	12.2	9.4	8.5
	April	36.4	51.7	12.4	41.6		11.1	10.9	12.7	10.9
	May	44.2	27.2	21.5	50.2		14.7	17.7	18.2	15.2
	June	48.8	5.1	27.1	35.5		20.8	22.7	20.8	20.0
	July	5.5	4.5	14.3	11.1		24.6	28.9	26.2	24.1
	August	18.3	6.6	45.8	17.3		25.2	27.9	25.4	23.7
	Sum	386.5	284.5	294.7	384.7	Mean	13.8	14.7	14.9	13.5
BONE	September	14.0	14.0	48.0	37.7		21.6	23.0	19.7	20.0
	October	46.5	74.5	81.0	44.0		15.3	18.4	16.5	14.0
	November	6.0	49.0	20.0	36.0		8.4	10.8	8.6	9.5
	December	43.0	52.0	8.0	33.4		5.8	6.6	5.2	6.0
	January	0.0	6.0	3.0	24.6		5.5	5.5	5.9	5.1
	February	149.0	25.5	0.0	30.2		4.9	5.9	8.3	6.4
	March	68.0	1.2	13.0	27.3		9.3	5.8	8.7	9.4
	April	19.8	64.0	20.0	37.8		10.5	12.5	12.1	11.9
	May	20.5	15.5	0.0	47.6		13.8	14.2	17.1	15.5
	June	23.5	2.4	44.5	39.6		20.3	17.5	19.8	19.5
	July	29.0	0.0	0.0	11.2		24.4	21.0	24.1	23.1
	August	4.0	5.3	24.0	14.5		23.9	23.5	22.6	22.7
	Sum	423.3	309.4	261.5	384.0	Mean	13.6	13.7	14.1	13.6

Source: Meteorological National Institute.
Locations: AGNU = Aguas Nuevas; CHIN = Chinchilla and BONE = Bonete.

differences between locations for all components. For instance, Delogu et al. (2002) for varieties of triticale in Italy or Kim et al. (2005) for varieties of rye in South Korea. In general, the values obtained for the qualitative components in the first two years were similar, and differed from those of the third year.

The differences in CP content (mean for six winter cereals) between the first and second years were not significant, although they were with respect to the third year for $p\leq 0.05$. Generally, the CP values obtained in the first and second years were higher than those for the third (Table 4). The study of the interactions among the location, year and cereal factors for CP content showed that the only significant result was the year×cereal interaction in the July sampling (Table 3), indicating that in the third year, the CP content was particularly low for the rye. The CP content in all cereals falls as the crop ripens, from April to July in whatever year, which is in line with what was reported by Tedla et al. (1992) for oats, Hadjipanayiotou et al. (1996) for oats and barley (Coffey et al., 2002) for rye and Delogu et al. (2002) and Zamora et al. (2002) for triticale.

In the April sampling, the cereal with highest mean CP content was rye with 16.56%. According by other studies, the results in the same vegetative stage are very variable

Table 3. Significance of main effects and their interactions in analysis of variant for quality and forage yield of winter cereals

Sampling periods	Source	df	Qualitative components				Production		
			CP	ADF	NDF	MFU	kg DM/ha	MFU/ha	kg CP/ha
April	Location	2	NS	NS	NS	NS	***	*	***
	Year	2	***	***	***	***	***	***	***
	Cereal	5	***	***	***	***	***	***	***
	Location×year	4	NS	NS	NS	NS	*	***	*
	Location×cereal	10	NS	***	NS	**	***	***	***
	Year×cereal	10	NS	NS	NS	**	***	***	***
	Location×year×cereal	20	NS	NS	NS	NS	***	***	***
	Error	162							
	Total	216							
June	Location	2	NS	NS	NS	NS	***	*	*
	Year	2	***	**	***	**	***	***	***
	Cereal	5	***	***	***	***	***	***	***
	Location×year	4	NS	NS	*	NS	*	***	NS
	Location×cereal	10	NS	***	***	**	NS	*	NS
	Year×cereal	10	NS	NS	NS	NS	***	*	***
	Location×year×cereal	20	NS	NS	NS	NS	NS	*	NS
	Error	162							
	Total	216							
July	Location	2	NS	NS	NS	NS	***	**	***
	Year	2	***	**	***	***	***	***	***
	Cereal	5	***	***	***	***	***	***	***
	Location×year	4	NS	*	NS	NS	***	**	***
	Location×cereal	10	NS	***	***	**	***	***	***
	Year×cereal	10	***	***	NS	**	***	***	***
	Location×year×cereal	20	NS	**	NS	NS	*	**	**
	Error	162							
	Total	216							

df = Degrees of freedom.
CP = Crude protein, ADF = Acid detergent fiber, NDF = Neutral detergent fiber, DM = Dry matter and MFU = Milk feed units.
*, **, *** Significant at the 0.05, 0.01, 0.001 probability levels, respectively. NS = Not significant at the 0.05 level.

(Options Mediterraneennes 1990; Ciria et al., 1996) to the extent that authors such as Kim et al. (2005) report values in the same study that range from 12.9 to 22.4%. The lowest values were returned by BarC and BarA, with 13.17 and 12.23% respectively. In the June sampling, OatP (11.67%) and OatS (11.42%) were the highest CP content. Rye and Trit fell appreciably in their CP content, and gave the lowest values, at 9.11 and 9.32%, respectively. For the July sampling, OatP presents the highest value in CP content, with 9.80%, followed by the two BarC and BarA varieties. The lowest values for this sampling were found in rye, due mainly to the value of 5.16% recorded in the third year, which was associated with a very low grain production. The differences found between the oat varieties were significant in the July sampling. Differences between varieties of barley were significant for the April and June sampling.

The values for ADF and NDF in the first year were generally lower than those in the second and third (Table 4). This figure could partly be explained by a higher rainfall in spring for the first year. The interactions between the three factors varied according to the type of fiber considered and the sampling period (Table 3), with the greatest differences appearing in the ADF interactions in the July sampling, showing that the model response front annually climatic conditions are different for each cereal.

As with other forages, the chemical composition varies with the growth stage of plants (Firdous and Gilani, 2001; Kim et al., 2001b). These variations may also affect the concentration of micronutrients minerals (copper, iron, zinc, and manganese) according to Khan et al. (2006 and 2007). The fiber content increased as the crops ripened, which is in agreement with what has been reported by authors such as Tedla et al. (1992) with oat, Hadjipanayiotou et al. (1996) with barley and oat, Delogu et al. (2002) and Zamora et al. (2002) with triticale. In the April sampling we found significant differences in the ADF and NDF contents of the different cereals. The lowest values of ADF and NDF content appeared in the two oat varieties. In this sampling, BarC presents the highest value of ADF with 26.25% while for NDF, it is rye, with 45.36%. In the June sampling rye returns the highest ADF values (32.61%) and the highest

Table 4. Crude protein (CP), acid detergent fiber (ADF), neutral detergent fiber (NDF) and relative feed value (MFU) of six winter cereals

		CP (%)			ADF (%)			NDF (%)			MFU		
	Cereal	April	June	July	April	June	July	April	June	July	April	June	July
Year 1	Trit	14.62	9.79	7.99	21.82	29.93	38.56	40.46	47.01	54.46	0.902	0.761	0.639
'92-'93	OatP	13.85	12.34	10.42	20.65	29.34	36.26	37.85	42.57	49.36	0.913	0.804	0.700
	OatS	14.24	12.46	10.18	19.93	32.31	40.36	34.34	40.62	51.70	0.937	0.787	0.651
	Rye	17.08	9.85	7.19	25.17	32.76	33.23	43.95	46.27	47.50	0.876	0.740	0.712
	BarC	13.80	11.82	9.80	25.94	27.25	33.04	38.81	46.78	54.90	0.867	0.804	0.703
	BarA	13.07	10.81	9.40	24.37	28.21	31.82	39.57	46.20	53.42	0.874	0.791	0.716
	Mean	14.44	11.18	9.16	22.98	29.97	35.54	39.16	44.91	51.89	0.895	0.781	0.687
Year 2	Trit	14.91	9.60	8.80	22.13	30.16	37.42	40.32	47.06	52.41	0.901	0.757	0.663
'93-'94	OatP	14.34	11.85	9.48	20.54	28.99	38.68	36.57	47.24	56.90	0.922	0.784	0.640
	OatS	14.29	11.19	9.16	20.09	32.15	39.87	34.46	47.96	57.38	0.935	0.751	0.625
	Rye	16.78	9.46	6.66	24.83	31.53	35.82	45.43	51.15	54.88	0.935	0.729	0.656
	BarC	13.46	11.06	9.47	25.87	28.00	33.61	38.81	47.37	50.40	0.864	0.790	0.711
	BarA	12.58	10.16	9.73	24.55	27.56	33.89	41.07	46.58	50.38	0.863	0.791	0.710
	Mean	14.39	10.55	8.88	23.00	29.73	36.55	39.44	47.89	53.72	0.904	0.767	0.668
Year 3	Trit	12.86	8.59	6.73	22.67	31.75	36.96	41.85	48.33	52.51	0.875	0.731	0.652
'94-'95	OatP	12.83	10.83	9.51	21.49	30.97	38.42	38.62	59.90	59.45	0.895	0.709	0.634
	OatS	12.89	10.62	7.91	20.51	32.84	39.48	35.31	58.45	58.13	0.917	0.698	0.617
	Rye	15.83	8.03	5.61	26.07	33.55	34.09	46.69	47.44	57.93	0.846	0.715	0.651
	BarC	12.26	9.90	8.49	26.94	28.13	31.33	41.29	47.99	49.74	0.835	0.777	0.727
	BarA	11.05	8.24	8.21	25.01	29.75	29.50	42.76	48.94	50.40	0.839	0.747	0.739
	Mean	12.95	9.37	7.74	23.78	31.17	34.96	41.08	51.84	54.70	0.868	0.730	0.670
Mean	Trit	14.13	9.32	7.84	22.21	30.61	37.65	40.88	47.47	53.13	0.893	0.750	0.651
	OatP	13.67	11.67	9.80	20.89	29.77	37.79	37.68	49.90	55.24	0.910	0.766	0.658
	OatS	13.81	11.42	9.08	20.17	32.44	39.90	34.70	49.01	55.73	0.930	0.745	0.631
	Rye	16.56	9.11	6.49	25.36	32.61	34.38	45.36	48.29	53.44	0.886	0.728	0.673
	BarC	13.17	10.93	9.26	26.25	27.79	32.66	39.63	47.38	51.68	0.855	0.791	0.714
	BarA	12.23	9.74	9.11	24.64	28.51	31.74	41.13	47.24	51.40	0.859	0.776	0.722
	Mean	13.93	10.37	8.60	23.25	30.29	35.69	39.90	48.21	53.44	0.889	0.759	0.675
LSD p<0.05													
	Year	0.32	0.28	0.22	0.46	0.64	0.76	0.54	0.68	0.88	0.012	0.008	0.004
	Cereal	0.44	0.38	0.32	0.64	0.88	1.06	0.76	0.96	1.28	0.014	0.010	0.006

Cereal: Trit = Triticale; OatP = Oat cv. "Previsión"; OatS = Oat cv. "Saia"; Rye = Rye cv. "Gigantón"; BarC = Barley cv. "Cameo"; BarA = Barley cv. "Albacete".
Sampling periods: April, June, July.

NDF value is OatP, with almost 50%. In July the lowest fibre values were found in the two varieties of barley and the highest were in the two varieties of oat.

No significant differences were found between the three locations for the values of the forage quality expressed as MFU/kg DM (Table 3). The effect of the variables and their interactions appeared as similar except for the June sampling, where no significant effect was found in the interaction between year×cereal and location×year×cereal. In the April sampling, values ranged from the 0.93 MFU/kg DM of oats and the 0.86 MFU/kg DM in the two varieties of barley. The net energy values decreased in the following sampling, which was consistent with what Zamora et al. (2002). In June it was the two varieties of barley that showed the highest values (BarC 0.79 MFU/kg DM and BarA 0.78 MFU/kg DM), while the cereal with the lowest value was rye, with 0.73 MFU/kg DM. Oat and Trit showed the lowest quality in the July sampling due to the very low proportion of grain returned by the cereals, especially in the second and third years.

The differences in the production of dry matter (kg DM/ha) were significant for the variables location, year and cereal. Likewise significant are all the interactions in the three samplings performed, with the exception of location× cereal and location×year×cereal in the June sampling. When considered individually or in terms of interactions, the effects of the different variables showed a similar pattern for the production expressed in MFU/ha and kg CP/ha (Table 3).

Dry matter productions in the April, June and July

Table 5. Dry matter production (kg DM/ha) of six winter cereals sampled in April, June and July in three locations and during the three years

		April				June				July			
	Cereal	AGNU	CHMA	BONE	Mean	AGNU	CHMA	BONE	Mean	AGNU	CHMA	BONE	Mean
Year 1	Trit	1,745	1,930	1,792	1,822	3,508	3,958	3,686	3,717	4,521	6,847	5,769	5,712
'92-'93	OatP	1,302	1,456	1,615	1,458	2,259	2,757	2,392	2,469	5,063	5,069	5,597	5,243
	OatS	1,005	1,015	1,103	1,041	2,408	2,671	2,509	2,529	4,740	5,380	5,375	5,165
	Rye	2,282	2,159	2,344	2,261	3,770	4,550	3,940	4,087	6,097	6,576	6,399	6,357
	BarC	1,304	2,239	1,500	1,681	3,515	4,684	3,899	4,033	4,735	6,337	6,542	5,871
	BarA	1,794	1,809	1,371	1,658	3,516	3,922	3,875	3,771	6,354	7,534	7,276	7,055
	Mean	1,572	1,768	1,621	1,654	3,163	3,757	3,383	3,434	5,251	6,290	6,160	5,900
Year 2	Trit	1,210	1,539	1,589	1,446	1,906	2,146	2,027	2,026	2,879	3,314	3,669	3,287
'93-'94	OatP	1,045	1,235	923	1,068	1,705	1,888	1,831	1,808	2,779	3,255	3,029	3,021
	OatS	707	791	819	772	1,771	2,378	2,499	2,216	2,705	3,056	2,975	2,912
	Rye	1,657	1,949	1,835	1,813	2,576	2,652	2,457	2,562	3,981	4,740	5,477	4,732
	BarC	1,146	1,224	1,320	1,230	1,915	2,051	2,039	2,001	4,344	4,997	4,981	4,774
	BarA	1,526	1,617	1,498	1,547	2,185	2,082	2,748	2,338	4,818	5,164	4,814	4,932
	Mean	1,215	1,392	1,330	1,313	2,010	2,199	2,267	2,159	3,584	4,087	4,157	3,943
Year 3	Trit	800	889	976	889	1,056	1,326	1,149	1,177	1,450	1,858	1,995	1,768
'94-'95	OatP	739	716	817	757	1,039	976	1,080	1,032	1,922	1,722	1,403	1,682
	OatS	726	717	969	804	1,021	1,141	1,026	1,062	1,425	1,605	1,343	1,457
	Rye	952	1,047	1,015	1004	1,339	1,193	1,425	1,319	2,291	2,854	2,648	2,598
	BarC	751	797	799	782	1,125	1,302	1,189	1,205	1,920	2,555	2,793	2,423
	BarA	979	880	1,030	963	1,376	1,462	1,456	1,431	2,626	3,156	2,564	2,782
	Mean	825	841	934	867	1,159	1,233	1,221	1,204	1,939	2,292	2,124	2,118
Mean	Trit	1,252	1,453	1,452	1,386	2,156	2,476	2,287	2,307	2,950	4,006	3,811	3,589
	OatP	1,029	1,136	1,118	1,094	1,668	1,873	1,768	1,770	3,255	3,348	3,343	3,315
	OatS	813	841	964	872	1,733	2,063	2,011	1,936	2,957	3,347	3,231	3,178
	Rye	1,630	1,718	1,731	1,693	2,562	2,798	2,607	2,656	4,123	4,723	4,841	4,562
	BarC	1,067	1,420	1,206	1,231	2,185	2,679	2,376	2,413	3,666	4,629	4,772	4,356
	BarA	1,433	1,435	1,299	1,389	2,359	2,489	2,693	2,513	4,599	5,284	4,885	4,923
	Mean	1,204	1,334	1,295	1,278	2,110	2,396	2,290	2,266	3,592	4,223	4,147	3,987
LSD	$p<0.05$		April				June				July		
	Location		84				150				192		
	Year		84				150				192		
	Cereal		120				212				272		

Sampling periods: April, June, July.

Locations: AGNU = Aguas Nuevas; CHIN = Chinchilla and BONE = Bonete.

Cereal: Trit = Triticale; OatP = Oat cv. "Previsión"; OatS = Oat cv. "Saia"; Rye = Rye cv. "Gigantón"; BarC = Barley cv. "Cameo"; BarA = Barley cv. "Albacete"

samplings in the CHMA and BONE locations were very similar (Table 5), and they were always higher than those of AGNU ($p\leq0.05$). For all the samplings in all the locations, the first year was significantly more productive because of a greater abundance of rainfalls. The average accumulated rainfalls and temperatures in the second and third years were very similar and yet the productions of the second year were significantly higher than those of the third. The explanation may lie in the fact that the rainfall between February and June (late winter and spring) in the third year was much lower than in the second (117.2 mm vs. 55.7 mm en AGNU, 115.1 mm vs. 81.9 mm in CHMA and 108.6 mm vs. 77.5 mm in BONE).

Dry matter productions differed significantly between cereal species in all the samples. In April, rye stood out as the most productive with an overall average of 1,693 kg DM/ha. The biggest production was 2,344 kg DM/ha for the first year in the BONE location, while the smallest was 952 kg DM/ha in AGNU in the third year. Other authors (Kim et al., 2005) reported rather higher values (near to 6,000 kg DM/ha) for rye. These differences may be accounted for by the varieties used and/or the type of soil since rainfall and temperature did not differ much from those in the study cited. The least productive species were OatP (1,094 kg DM/ha) and OatS (872 kg DM/ha), with a minimum of 717 kg DM/ha for OatS in the location of CHMA in the third year.

Significant differences also existed in dry matter

Table 6. Production of forage units (MFU/ha) of six winter cereals sampled in April, June and July in three locations and during the three years

		April				June				July			
		AGNU	CHMA	BONE	Mean	AGNU	CHMA	BONE	Mean	AGNU	CHMA	BONE	Mean
Year 1	Trit	1,537	1,761	1,634	1,643	2,627	2,930	2,925	2,829	3,051	4,340	3,510	3,650
'92-'93	OatP	1,177	1,349	1,469	1,332	1,700	2,273	1,998	1,986	3,427	3,625	3,961	3,669
	OatS	925	964	1,037	975	1,911	2,042	2,017	1,991	3,283	3,562	3,215	3,362
	Rye	1,970	1,915	2,054	1,980	2,597	3,514	2,990	3,024	4,001	4,878	4,728	4,528
	BarC	1,111	1,970	1,302	1,457	2,803	3,660	3,253	3,244	3,533	4,511	4,253	4,126
	BarA	1,539	1,614	1,196	1,449	2,598	3,233	3,133	2,981	4,151	5,626	5,436	5,049
	Mean	1,383	1,605	1,453	1,479	2,383	2,948	2,726	2,683	3,589	4,415	4,158	4,052
Year 2	Trit	1,064	1,403	1,450	1,303	1,418	1,568	1,614	1,534	1,901	2,273	2,360	2,180
'93-'94	OatP	952	1,156	849	985	1,285	1,525	1,450	1,418	1,711	2,160	1,943	1,934
	OatS	645	752	771	722	1,339	1,755	1,893	1,663	1,734	1,903	1,818	1,820
	Rye	1,511	1,855	1,728	1,696	1,812	1,988	1,806	1,868	2,451	3,270	3,626	3,104
	BarC	967	1,074	1,151	1,063	1,504	1,571	1,671	1,582	3,034	3,690	3,467	3,394
	BarA	1,294	1,428	1,284	1,335	1,645	1,709	2,193	1,849	3,056	3,935	3,538	3,504
	Mean	1,075	1,279	1,208	1,186	1,506	1,691	1,775	1,656	2,309	2,836	2,764	2,633
Year 3	Trit	686	787	862	777	761	941	874	860	1,059	1,164	1,196	1,153
'94-'95	OatP	656	651	726	678	691	721	782	731	1,212	1,111	877	1,066
	OatS	650	667	898	737	696	778	748	742	904	984	808	899
	Rye	790	908	854	850	891	887	1,050	943	1,399	1,926	1,764	1,690
	BarC	610	675	675	653	858	995	958	937	1,428	1,859	1,983	1,762
	BarA	806	754	862	808	969	1,120	1,123	1,070	1,722	2,478	1,991	2,057
	Mean	701	742	813	752	811	905	921	879	1,295	1,556	1,409	1,419
Mean	Trit	1,092	1,312	1,311	1,237	1,591	1,800	1,792	1,729	2,031	2,599	2,352	2,338
	OatP	927	1,050	1,013	996	1,207	1,481	1,385	1,355	2,087	2,259	2,200	2,181
	OatS	739	794	902	811	1,290	1,503	1,536	1,443	1,940	2,118	1,950	2,005
	Rye	1,416	1,550	1,535	1,500	1,757	2,113	1,939	1,934	2,587	3,316	3,336	3,070
	BarC	892	1,233	1,040	1,053	1,708	2,064	1,947	1,908	2,675	3,361	3,271	3,109
	BarA	1,208	1,260	1,112	1,193	1,727	2,000	2,134	1,951	2,980	4,041	3,677	3,553
	Mean	1,049	1,205	1,155	1,135	1,550	1,827	1,789	1,720	2,389	2,920	2,769	2,690
LSD	$p<0.05$	April					June				July		
	Location	72					112				130		
	Year	72					112				130		
	Cereal	102					160				184		

Sampling periods: April, June, July.

Locations: AGNU = Aguas Nuevas; CHIN = Chinchilla and BONE = Bonete.

Cereal: Trit = Triticale; OatP = Oat cv "Previsión"; OatS = Oat cv"Saia"; Rye = Rye cv. "Gigantón"; BarC = Barley cv. "Cameo"; BarA = Barley cv. "Albacete"

production in the June sampling although these was not so marked as in the previous sampling. Rye production at 2,656 kg DM/ha was equal to that of BarA, with 2,513 kg DM/ha. OatP and OatS again returned the lowest values in June (1,770 and 1,936 kg DM/ha). Noro et al. (2003) found that rye was the most productive when they compared it to triticale and barley in a study covering the same period. In the July sampling, BarA production (4,923 kg DM/ha) was significantly higher than that of rye with 4,562 kg DM/ha. Average production for the other cereals was below 4,000 kg DM/ha.

An observation of the growth dynamics of the crops led us to deduce that there are differences between the cereals. Rye had a high initial growth rate. Rye was the most productive cereal in the April sampling and then it leveled out. The barleys showed a more regular growth rate over the cycle, with BarA being the most productive in the last sampling. Unlike rye, OatP and OatS, showed a slow growth rate at the beginning and a more accelerated one at the end, although they never reached the productions of the other cereals in the climatic and soil conditions of this study.

In terms of MFU/ha (Table 6) the production increased significantly in each sampling since the increase in production in kg DM/ha always made up for the decrease in forage quality (MFU/kg DM). The only exceptions were the April production of rye in CHMA, which was similar to that of June (908 vs. 887) and the April production of OatS in BONE, which was higher than the June one (898 vs. 748). When expressing production in terms of kg CP/ha, rye presented lower values in the April sampling in the second

Table 7. Production of protein (kg CP/ha)of six winter cereals sampled in April, June and July in three locations and during the three years

		April				June				July			
		AGNU	CHMA	BONE	Mean	AGNU	CHMA	BONE	Mean	AGNU	CHMA	BONE	Mean
Year 1	Trit	255	280	264	266	344	391	357	364	360	553	458	456
'92-'93	OatP	183	202	221	202	286	339	289	305	535	529	574	546
	OatS	145	145	155	148	308	338	299	315	491	552	532	526
	Rye	393	365	402	386	371	448	388	402	443	478	450	457
	BarC	182	305	207	232	414	552	464	477	469	624	631	575
	BarA	235	236	178	217	386	421	415	408	601	708	679	663
	Mean	229	254	234	239	358	421	373	384	486	580	555	541
Year 2	Trit	179	230	239	216	183	204	196	194	249	294	326	289
'93-'94	OatP	150	177	133	153	203	223	217	214	261	310	288	286
	OatS	101	114	116	110	199	265	279	248	250	280	270	267
	Rye	285	323	304	304	241	252	234	242	264	316	366	315
	BarC	153	167	177	166	214	224	227	221	410	476	471	452
	BarA	195	206	183	195	233	210	267	238	465	501	473	480
	Mean	175	201	190	189	214	231	238	228	317	364	370	350
Year 3	Trit	103	114	126	114	92	114	97	101	98	125	135	119
'94-'95	OatP	94	92	106	97	116	104	115	112	184	163	133	160
	OatS	94	93	124	104	107	121	111	113	110	128	108	115
	Rye	150	168	159	159	108	95	114	106	129	159	149	146
	BarC	91	96	101	96	114	129	115	119	163	218	236	206
	BarA	111	96	113	106	114	118	122	118	216	259	210	228
	Mean	107	109	122	112	110	115	114	113	150	177	165	164
Mean	Trit	176	204	207	196	202	231	212	215	229	316	299	281
	OatP	141	155	153	150	198	217	204	207	321	328	326	325
	OatS	113	117	132	120	199	236	227	221	269	306	291	289
	Rye	272	284	285	280	233	255	238	242	268	307	312	296
	BarC	140	186	160	162	241	291	259	264	340	430	438	403
	BarA	178	176	157	170	235	240	258	245	419	481	445	449
	Mean	168	185	180	178	221	248	236	235	309	364	355	343
LSD	$p<0.05$		April				June				July		
	Location		14				18				18		
	Year		14				18				18		
	Cereal		18				24				26		

Sampling periods: April, June, July.
Locations: AGNU = Aguas Nuevas; CHIN = Chinchilla and BONE = Bonete.
Cereal: Trit = Triticale; OatP = Oat cv. "Previsión"; OatS = Oat cv. "Saia"; Rye = Rye cv. "Gigantón"; BarC = Barley cv. "Cameo"; BarA = Barley cv. "Albacete".

and third years than in the June ones. The same phenomenon occurred in the location of AGNU in the first year. For all the other species, the amounts of kg CP/ha increased with time, with the greatest quantities coming in July and the lowest ones in April. This result was consistent with what was stated above about the dynamics of forage production and reflects that a sharp fall in the metabolic growth and development rate of the plant led to a lower proportion of protein content. The highest CP productions were observed in year 1; 663 and 575 kg/ha, in BarA and BarC, respectively (Table 7).

Given these results, we can conclude that in the conditions of our study location influenced on forage production but not on forage quality. The year was of influence because of the climatic conditions which occurred therein, with lower production and lower quality forage in years of lower rainfall. When comparing productions, rye was the most suitable cereal for early exploitation on account of its initial growth rate. For later exploitation, barley cv "Albacete" was the most appropriate.

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