CORN OR SORGHUM / ITALIAN RYEGRASS FORAGE ROTATION UNDER DIFFERENT CULTIVATION SYSTEMS IN HIGH RAINFALL AREAS OF SPAIN

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ABSTRACT
A field assay was established at three locations in northern Spain with the main objective of characterizing forage production and evaluating no-tillage methods as an alternative to the conventional labour practices. Three fields located in Guntìn (Galicia), Grado (Asturias) and Derio (Basque Country) were sown different rotations: Italian ryegrass (*Lolium multiflorum* L.)-corn *(Zea mays* L.) and Italian ryegrass-sorghum (Sorghum bicolor (L.) Moench x sudangrass) under two different systems: conventional tillage (T) and no-tillage (NT). Italian ryegrass-corn rotation was more productive than the sorghum x sudangrass rotation in the three sites, with average forage yield varying from 17.8 t DM/ha in Derio to 15.0 t DM/ha in Guntìn. Corn under T treatment produced more than NT treatment (10.5 and 8.9 t DM/ha, respectively). Yield achieved in the T system was not large enough to compensate the extra labour cost involved in the T system.

KEYWORDS
Tillage, no-tillage, sowing methods, forage yield, dairy farms, Cantabric coast.

INTRODUCTION
In spite of introduction of milk quotas, farms located in northern Spain have increased milk production to a range from 5000 to 7000 kg milk/cow/year, but the main basis of this production are the supplements from outside of the farm which represent at least 31% of the milk benefits (Oyanarte *et al.*, 1994). In order to reduce this percentage it is necessary to increase forage resources. Several studies have considered the corn-Italian ryegrass rotation as an efficient way to increase forage production in dairy farms although labour costs are the main constraint for forage rotations especially when farms are small and with difficult structure.

In rainy areas no-tillage systems in comparison with conventional ones appear to be an easier labour which makes labour cost cheaper and minimizes soil erosion. Although no-tillage systems are of common use in other countries, it is a quite new system in northern Spain (Balza, 1994) and it should be considered as a profitable alternative management to conventional practices. The objective of this work is to evaluate the potential of forage rotation and to compare the efficiency and economics of surface seeding compared with conventional cultivation.

METHODS
In 1993 three fields were established in northern Spain: Derio (Basque Country) at 52 masl, Grado (Asturias) at 50 masl and Guntín (Galicia) at 580 masl. High rainfall (1295 mm) and mild temperature (mean of 13.5°C) are characteristics of this area. A split-plot experimental design with four replications was used. Main plot consisted of crop rotation and the subplot was the tillage system. The crop rotations used were Italian ryegrass-corn and sorghum*sudangrass with two sowing systems, tillage (T) and no-tillage (NT). Field operations and herbicide applications are shown in Table 1. The experimental assay was established in 1993, but in this work is described data coming from the period Sep. 1994-Sep. 1995, considering the previous year as an establishment year for the system. Italian ryegrass was cut at 25-30 cm height by a mowing machine and corn was harvested for silage and shorghum*sudangrass was harvested at a height of 50 cm. Analysis of variance was performed using the SAS Anova procedure. Yield means were separated by Duncan at 5% confidence level. Data from corn-Italian ryegrass rotations was used for the economic evaluation. Labour cost has been calculated assuming standard market prices for labour and for materials ($963/ha for fertilizers, herbicides and seed). A price of $0.05/kg for green corn 35% DM and $0.12/kg DM for Italian ryegrass, are considered for the conversion of produced forage in monetary terms.

RESULTS AND DISCUSSION
Total forage yield showed significant differences between the three locations and the production was higher under the Italian ryegrass-corn rotation than the Italian ryegrass-sorghum rotation in all the places, with values of 17.8 and 12.5 t DM/ha for each rotation at Derio, 17.0 and 11.9 t DM/ha at Grado, 15.0 and 12.0 t DM/ha at Guntìn. Sowing method had a significant effect on annual forage yield, 14.9 and 13.9 t DM/ha were achieved for T and NT treatment, respectively. Although there was not any significant interaction between rotation and sowing methods, at all locations the T system in corn produced more than the NT system, whereas in the sorghum rotation, there was not any difference between the two sowing methods.

When corn and sorghum yields are considered separately from Italian ryegrass, Derio got larger productions than the other locations. Derio produced 12.0 and 10.0 t DM/ha of corn for T and NT treatment, whereas Grado and Guntìn produced an average of 9.7 and 8.2 t DM/ha. Sorghum rotation yield was significantly lower than corn rotation yield ($P<0.001$) with a mean value of 5.4 t DM/ha for the three locations. Corn yield was consistently higher in the T treatment compared with the NT treatment (Table 2) although only 1.6 t DM/ha higher. At Derio, there was a clear effect of the no-tillage method on crop system, root length was smaller and roots were closer to the soil surface, and this agrees well with results of others authors (Roth et al., 1995). This fact might have decreased corn yield, however, the different development of sorghum roots did not appear to be related to sorghum yield.

Economic benefits of sowing systems did not show a great difference. The T system gave benefits of $578 vs $702 for the NT system. Labour cost in the T system was higher than in the NT ($2233 vs $2009) and this cost increases with the amount of herbicide and the time use in land preparation. The effect of the NT in the reduction of the time needed for cultural practices is remarkable, 8.7 h for the NT system compared with 24 h in the T system, that means a reduction of 64% of the time consumed. On the other hand, time inter crops was roughly 4 weeks in the T method whereas in the NT it was reduced to 2 weeks if the seeding takes place immediately after herbicide application. In our conditions the T system only would be more profitable than the NT if the difference between achieved yields would be higher than the one we obtained.

Weed invasion during the corn crop was higher in the NT system, especially at Derio. In this case, the cost of the NT system would increase if more herbicide would be needed for weed control. Some

authors (Thom and Barker, 1993) have confirmed that the use of the herbicide reduces the differences in the cost between both systems. Other systems, like intercropping may be considered as a way to reduce herbicide costs and prevent the herbicide-resistant and perennial weed population.

ACKNOWLEDGEMENTS
This work was supported by the Instituto Nacional de Investigación y Tecnología Agraria y Alimentaria (INIA). Ref:SC93-100-C3.

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Table 1
Field operations and herbicide applications

	Conventional tillage (T)	No-tillage (NT)
Sept. 94	* Rotavator	* Fertiliser application: 150 kg P_2O_5 ha^{-1} and 125 kg K_2O ha^{-1}
	* Fertiliser application: 150 kg	* 45 kg ha-1 Italian ryegrass
	* Rotavator	* Fertiliser application: 140-180 kg N ha^{-1}
	* 45 kg ha-1 Italian ryegrass	
	* Compact roller	
	* Fertiliser application: 140-180 kg N ha^{-1}	
May 95	* Rotavator	* Herbicide application: 3 L ha^{-1} Glyphosate
	* Moldboard ploughing	* Fertiliser application: 125 kg K_2O ha^{-1}
	* Fertiliser application: 125 kg K_2O ha^{-1}	* 115.000 plants ha-1 corn and 45 kg ha^{-1} sorghum direct-drilling (NT)
	* Rotavator 6 L ha^{-1} (alachlorine + atrazine) in corn 6 L ha^{-1} propachlorine + 1.5 L ha^{-1} atrazine in sorghum	* Preemergence herbicide application:
	* 110.000 plants ha^{-1} corn and 45 kg ha-1 sorghum conventional tillage (CT)	* Fertiliser application: 140 kg N ha^{-1}
	* Preemergence herbicide application: 6 L ha^{-1} (alachlorine + atrazine) in corn 6 L ha^{-1} propachlorine + 1.5 L ha^{-1} atrazine in sorghum	
	* Fertiliser application: 140 kg N ha^{-1}	

Table 2
Effect of sowing system on corn and sorghum yield for the three locations

	Corn		Sorghum	
	T	NT	T	NT
Yield, t DM/ha	10.5 a	8.9 b	5.2 a	5.6 a

Values for the same crop with different letters are different at the 0.05 significance level according to the Duncan Test