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SHORT COMMUNICATION

Low vs high "water footprint assessment" diet in milk production: A comparison between triticale and corn silage based diets

C. Cosentino*, F. Adduci, M. Musto, R. Paolino, P. Freschi, G. Pecora, C. D'Adamo and V. Valentini

School of Agricultural, Forestry, Food, and Environmental Sciences.University of Basilicata Viale dell'AteneoLucano. 85100 – Potenza, Italy

Abstract

The agriculture account is 92% of the global freshwater footprint, and 29% of this amount is used in animal husbandry to produce forage, to mix animal feed, for drinking of the animals and, at least, in the farm activities. In this trial we tested two diets whose production is characterized by different water consumption. Two homogeneous groups of milking cows were used to compare two different diets: standard feeding, with corn silage-based diet; and alternative feeding, with triticale silage-based diet. Both silages represented about 47% of diet composition. Diets were characterized by the same energy and protein content. Despite the lowest water consumption of the triticale silage group, no significant differences were observed between the groups on production level and on milk chemical composition.

Key words: Cow, Diet, Milk, Water footprint

Introduction

Some authors estimated that our dependence on water resources will increase significantly in the future and this will bring problems for future food security and environmental sustainability (Alcamo et al., 2003a; Bruisma, 2003, 2009; Rosegrant et al., 2002, 2009). To better understand the linkage between freshwater resource and human productive activities, Water Footprint Assessment (WFA) was developed to measure the amount of consumed water and water pollution. This concept was introduced by Hoekstra (2003) and it was also elaborated by Chapagain et al. (2003).

The dairy cow feeding plays a crucial role in economic and technical efficiency of the livestock, with an incidence of about 60% on the total costs, and diet formulation is one of the main factors that influence the lactation cow health state as well as quality and quantity of produced milk (Dell'Orto and Savoini, 2005).

Dairy cows feeding in the world is mainly based on corn silage, while the triticale is used as forage for livestock, and it can be crop as a mono-crop, or mixed with other cereals or with legumes. In general, WFA is lower in triticale than in other small grain forage cereals (Rao et al., 2000). In fact, triticale has a biological cycle that develops during cold season (corn microtherm), and it prefers high temperatures at the end of its cycle, therefore WFA is lower than in corn that shows an opposte behavior in terms of thermal and water requirements.

Considering the lowest WFA of triticale, in this study were evaluated the effects of replacing corn silage with triticale silage on milk production in Italian Friesian cows.

Materials and Methods

A group of ninety multiparous Holstein Frisian cows reared in a farm situated at an altitude of 580 m a.s.l., weigthing 650±10 kg and at 21±15 days of lactation, were divided in two homogeneous groups of 45 individuals, and reared with freestall barns in covered shed, with bunks placed head-to-head.

Diet composition and feeding

We utilized two different diets: standard feeding (SF) and alternative feeding (AF).

SF was based on corn silage feed composed of corn silage (50.31%), alfa hay (8.81%), rye grass hay (5.30%), maize meal (12.04%), soybean meal (7.80%), distillers (5.30%), beet pressed pulp (1.26%), calcium soaps (0.75%), cotton seed

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*Corresponding Author

C. Cosentino
School of Agricultural, Forestry, Food, and Environmental Sciences.University of Basilicata Viale dell'AteneoLucano. 85100 - Potenza. Italy.

Email: carlo.cosentino@unibas.it

(1.01%), vitamin mineral supplement (1.13%) and water (6.29%).

AF group was fed on a based triticale silage feed composed of triticale silage (50.25%), alfa hay (6.78%), maize meal (8.79%), soybean meal (8.04%), beet pressed pulp (1.51%), maize gluten meal (1.51%), hay vetch/oats (3.77%), flaked maize (6.78%), cotton seed (2.51%), vitamin mineral supplement (1.27%) and water (8.79%).

The nutrient requirements and the level of daily ingestion in both groups were determined by CPM dairy ration analyzer ver. 3.0.7 (Tedeschi et al., 2006, 2008; Alderman, 2001; Allen et al., 2005; Lanzas et al., 2007). Therefore the basis level of diet ingestion was 39.75 kg as feed (21.58 kg of DM) per head/die in SF group, and 39.80 kg as feed (21.62 kg of DM) head/die in AF group.

The individual monitoring of production was determined in the lactation period, from the 3rd to the 17th week (105 days) after one week of adaptation to new diets. In order to evaluate some important differences between estimated and observed dry matter intake during the test, the administered dry matter has increased of 3%, and finally the average dry matter intake, was for group SF and for group AF, 21.75 kg/die and 21.70 kg/die, respectively.

Quantitative and qualitative milk characteristics

The complete lactation curves in both groups were elaborated on farm data starting from farmer's information, in order to calculate the average of the milk production for whole lactation period. The individual milk sampling was conducted on both milkings every week. The qualitative milk analyses (fat and protein content) were determined by MilkoScan FT 6000 (Foss Electric A/S. Hillerød. Denmark).

Water footprint estimation

WFA milk calculation was determined by summing WF feed (for feed production), WF feed mixing (water used for feed mixing), WF drinking (water intake), and WF service for cleaning of the stable according to the following formula (Chapagain and Hoekstra, 2003 and 2004):

$$WFAmilk = WFfeed + WFfeed\ mixing + WFdrinking + WFservice$$

We estimated green, blue, and gray water, (water footprint classification) for indirect and direct water footprint and also kg of milk during trial period and for all standard lactation.

The “green water footprint” refers to soil moisture produced by land rainfall evaporation used for crop production or inside the product. The “blue water footprint” refers to evaporated surface water or groundwater, into the product or returned to other places. The “gray water footprint” is defined as the volume of freshwater that is required to assimilate the load of pollutants based on existing ambient water quality standards (Hoekstra et al., 2011).

For calculation of indirect water footprint of the feed used in both diets the literature data were utilized (Mekonnen and Hoekstra, 2012), while other fractions (drinking, mixing and service) have been assessed at the farm utilizing a mechanical water counter (CD74 TBR model).

The water used for mixing food was added to blue water component present into food ration.

Statistical analysis

Data concerning qualitative and quantitative milk characteristics of both groups were expressed as mean±S.E. Differences between groups were tested by Student’s *t*-test.

Results and Discussions

Qualitative and quantitative milk characteristics

No significant differences were found between the two groups in terms of milk production, during the trial period. The SF group showed an average production per animal of 38.27 kg during the test, and 30.94 kg for all lactation period; AF group showed an average production of 37.98 kg during the test, and 30.57 kg for all lactation period (Figure 1; Table 2).

The fat content (g/kg of milk), for both groups, was similar: 34.85±0.09 and 35.07±0.10 for SF group and for AF group, respectively. The protein content (g/kg of milk) was 33.12±0.09 and 33.28±0.10 for SF group and for AF group, respectively (Table 1). The trend of fat and of protein did not show any significant difference in both groups (Figure 2).

Water footprint estimation

Daily water footprint average per kg of milk was 501 liters (trial period) and 619 liters (all lactation period) for the SF group, and 436 liters (trial period) and 542 liters (all lactation period) per the AF group, respectively. Therefore, the WF difference per kg of milk was 64.74 liters (trial period) and 77.69 liters (all lactation period) between the two groups during the trial (Table 3). Green water has recorded a daily average incidence of 48.72% and 54.45% for SF and AF groups, respectively. Finally, as shown in Table 4, WF feed was higher in SF than in AF (17630 vs. 15020). This means that AF diet allowed a conspicuous water saving (>2600 liters for each dairy cow per day).

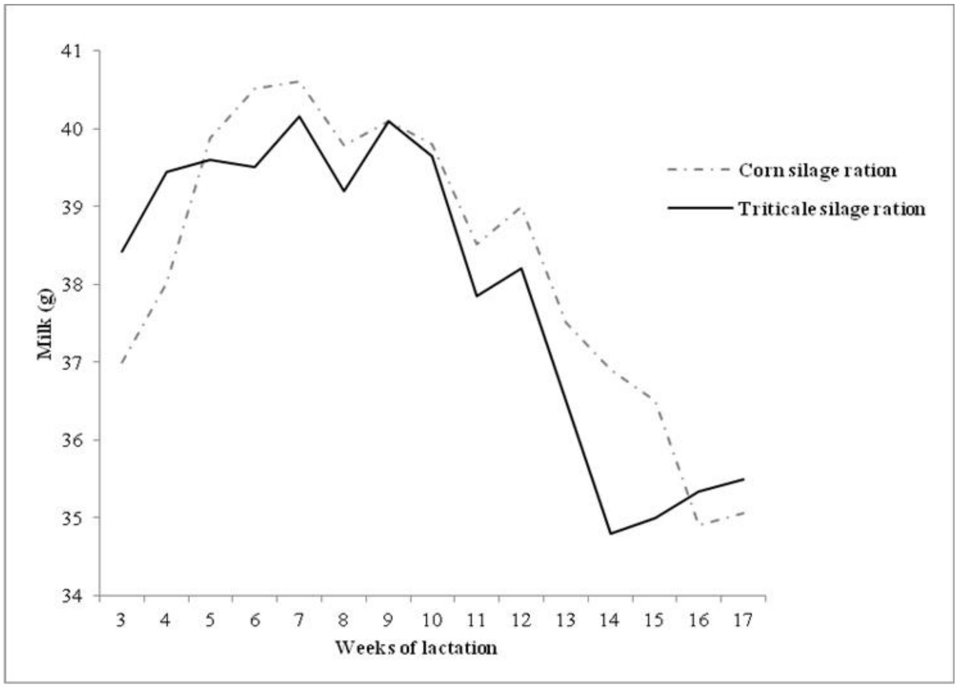

Figure 1. Milk yield level for AS and FS.

Table 1. Protein and fat.

	Fat g/kg of milk				Protein g/kg of milk			
Trial week	SF	S.E.	AF	S.E.	SF	S.E.	AF	S.E.
3	34.89	0.10	35.05	0.10	33.09	0.08	33.23	0.10
4	34.96	0.09	35.02	0.09	33.03	0.08	33.15	0.10
5	34.99	0.09	35.01	0.09	33.01	0.08	33.11	0.10
6	35.00	0.09	35.00	0.09	33.00	0.08	33.10	0.10
7	35.00	0.09	35.01	0.09	33.01	0.08	33.11	0.10
8	34.98	0.09	35.01	0.09	33.02	0.08	33.13	0.10
9	34.95	0.09	35.02	0.09	33.04	0.08	33.17	0.10
10	34.91	0.09	35.04	0.09	33.07	0.08	33.21	0.10
11	34.87	0.09	35.06	0.10	33.10	0.08	33.25	0.10
12	34.82	0.09	35.07	0.10	33.14	0.08	33.31	0.10
13	34.77	0.09	35.09	0.10	33.18	0.08	33.36	0.11
14	34.72	0.10	35.12	0.10	33.22	0.08	33.43	0.11
15	34.67	0.10	35.14	0.10	33.26	0.08	33.49	0.11
16	34.61	0.10	35.16	0.10	33.31	0.09	33.56	0.11
17	34.55	0.10	35.19	0.11	33.35	0.09	33.63	0.11
All	34.85	0.09	35.07	0.10	33.12	0.09	33.28	0.10

Table 2. Milk yield (kg).

Production (kg)				
	SF		AF	
Trial week	Mean	S.E.	Mean	S.E.
3	37.00	0.80	38.45	1.13
4	38.01	1.12	39.23	1.08
5	39.88	1.17	39.60	1.15
6	40.51	1.19	39.70	1.17
7	40.61	1.20	39.62	1.17
8	39.78	1.16	39.40	1.17
9	40.10	1.20	39.08	1.21
10	39.80	1.16	38.68	1.14
11	38.52	1.14	38.23	1.12
12	39.00	1.15	37.73	1.09
13	37.50	1.10	37.19	1.10
14	36.89	1.08	36.62	1.07
15	36.50	1.09	36.03	1.06
16	34.90	1.03	35.42	1.05
17	35.07	1.03	34.80	1.01
All	38.27	1.11	37.98	1.11

Figure 2. Fat and proteins content.

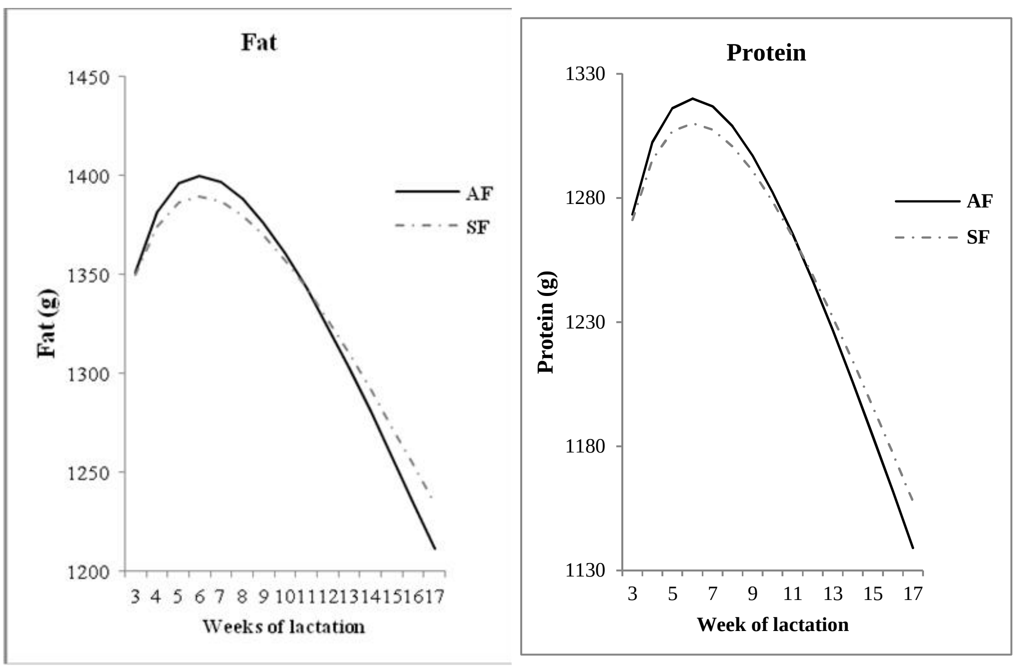

Table 3. Water footprint average of components per kg of milk (liters).

	Trial period			All period		
	SF	AF	Δ	SF	AF	Δ
blue	194.52	164.5	30.02	240.61	204.37	36.24
green	243.91	237.35	6.56	301.69	294.89	6.80
grey	62.22	34.06	28.16	76.96	42.32	34.64
Total water footprint (l)	500.66	435.91	64.74	619.27	541.58	77.69

Table 4. Trial period water footprint average (l/day/animal).

	Indirect water footprint		Direct water footprint		
Groups	WF_{Feed} (Estimated)	$WF_{Feed\ Mixing}$ (Observed)	$WF_{Drinking}$ (Observed)	$WF_{Service}$ (Observed)	WF Average l/day/ animal
SF	17630	2.5	90	1440	19163
AF	15020	3.5	90	1440	16554

Conclusions

Our results showed that there were no differences in milk productions of lactating dairy cows fed on diets containing triticale silage or corn silage. The largest water footprint for animal production comes from the feed they consume (SF: 92.01%; AF: 90.75%) according to many authors, while the incidence of drinking water, service water and feed-mixing water in both diets administered was quite low (<10%). Therefore, the use of triticale silage in dairy cow diets could be an effective alternative to corn silage.

The adoption of this type of silage should be further exploited, especially in world zones with limited water resource, as the use of triticale silage is important to formulate low WFA diets.

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Author contributions

C. C. designed the study, F. A. formulated the diets for the test, M. M. did statistical analysis, R. P. did chemical analysis, P. F. contributed to the review paper, G. P. was involved in milk sampling, C. D. was involved in forage sampling and V. V. performed the wfp assessment.

References

Alcamo, J., P. Doll, T. Henrichs, F. Kaspar, B. Lehner, T. Rosch and S. Siebert. 2003. Development and testing of the Water GAP 2 global model of water use and availability. Hydrol. Sci. J. 48(3):317-337.

Alderman, G. 2001. A critique of the Cornell Net Carbohydrate and Protein System with emphasis on dairy cattle. 1. The rumen model. J. Anim. Feed Sci. 10:1-24.

Allen, M. S., B. J. Bradfordand and K. J. Harvatine. 2005. The cow as a model to tudy food intake regulation. Annu. Rev. Nutr. 25:523-547.

Bruinsma, J. Editor, World agriculture. 2003. Towards 2015/2030: an FAO perspective. UK, London: Earthscan.

Bruinsma, J. 2009. The resource outlook for 2050: by how much do land. water and crop yields need to increase by 2050. expert meeting on how to feed the world by 2050. 24-26 June 2009. Rome. Italy: FAO.

Chapagain, A. K. and A.Y. Hoekstra. 2003. Virtual Water Flows Between Nations in Relation to Trade in Livestock and Livestock Products. Value of Water Research Report Series no. 13. UNESCO-IHE. Delft. the Netherlands.

Chapagain, A. K. and A. Y. Hoekstra. 2004. Water footprints of nations. Value of Water Research Report Series No. 16. Available online: [www. waterfootprint.org/Reports/Report16Vol1.pdf. Delft, the Netherlands: UNESCO-IHE.

Dell’Orto e Savoini, 2005. L'alimentazione responsabile della vacca da latte. Gestione responsabile dell'alimentazione per ottenere latte di alto standard qualitativo. Il Sole 24 Ore Edagricole, 2005.

Hoekstra, A. Y. (Ed.). 2003. Virtual Water Trade: Proceedings of the International Expert Meeting on Virtual Water Trade. Delft. the Netherlands. 12 and 13 December 2002. Value of Water Research Report Series No. 12. UNESCO-IHE. Delft. The Netherlands. www. waterfootprint.org/Reports/Report12.pdf.

Hoekstra, A. Y. and M. M. Mekonnen. 2011. Global Water Scarcity: Monthly Blue Water Footprint Compared to Blue Water Availability for the World’s Major River Basins. Value of Water Research Report Series No.53. UNESCO-IHE.

Lanzas, C., C. J. Sniffen, S. Seo, L. O. Tedeschi and D. G. Fox. 2007. A revised CNCPS feed carbohydrate fractionation scheme for formulating rations for ruminants. Anim. Feed Sci. Technol. 136:167-190.

Mekonnen, M. M. and A. Y Hoekstra. 2012. A global assessment of the water footprint of farm animal products. Ecosystems 15(3):401-415.

Rao, S. C., S. W. Coleman and J. D. Volesky. 2000. Yield and quality of wheat, triticale, and elytricum forage in the southern plains. Crop Sci. 40(5):1308-1312.

Rosegrant, M. W., X. Cai and S. A. Cline. 2002. Global water outlook to 2025.Washington DC. USA: International Food Policy Research Institute.

Rosegrant, M. W., C. Ringler and T. Zhu. 2009. Water for agriculture: maintaining food security under growing scarcity. Annu. Rev. Env. Resour. 34(1):205-22.

Tedeschi, L. O. 2006. Assessment of the adequacy of mathematical models. Agric. Syst. 89:225-247.

Tedeschi, L. O., W. Chalupa, E. Janczewski, D. G. Fox, C. Sniffen, R. Muson, P. J. Kononoff and R. Boston. 2008. Evaluation and application of the CPM dairy nutrition model. J. Agric. Sci. 146:171-182.