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in

Acar Z. (ed.), López-Francos A. (ed.), Porqueddu C. (ed.).
New approaches for grassland research in a context of climate and socio-economic changes

Zaragoza : CIHEAM
Options Méditerranéennes : Série A. Séminaires Méditerranéens; n. 102

2012
pages 327-331

Effect of deficit irrigation on dry matter and sheep production from permanent sown pastures

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Abstract. A three year study compared pasture and sheep production from permanent sown pastures that were irrigated at four levels in Konya, the Central Anatolia Region of Turkey. Pastures were established in 2007 with *Festuca rubra*, *Poa pratensis*, *Lolium perenne*, *Trifolium repens* and *Lotus corniculatus*, and irrigated at 100%, 75%, 50% or 25% of field capacity (FC). Established pastures were grazed rotationally by flocks of weaned lambs between 2008 and 2010. The total annual dry matter production (DMP) (kg/ha) was reduced (P<0.01) by decreasing levels of irrigation in each year. Averaged across the years, mean annual DMP was 9.59, 8.78, 7.21 and 4.86 t/ha for FC 100%, 75%, 50% and 25%, respectively. Pastures irrigated at FC 100% and 75% provided equal animal production but total liveweight production (LWP)/ha decreased (P<0.01) when pastures irrigated at FC 50% or at lower level in a similar manner in each year of the study.

Keywords. Pasture production – Deficit irrigation – Grazing – Irrigation efficiency – Lamb production.

Effet de l'irrigation déficitaire sur la production de matière sèche et la production ovine à partir des pâturages permanents semés

Résumé. *Une étude de trois ans ayant pour objectif de comparer la production ovine et celle du pâturage sur de différents niveaux d'irrigation a été conduite dans la région de Konya de l'Anatolie Centrale en Turquie. Les parcelles ont été semées en 2007 avec du* Festuca rubra*,* Poa pratensis*,* Lolium perenne*,* Trifolium repens *et* Lotus corniculatus *et ont été irrigués a de doses calculées á raison des % de capacité au champ de 100%, 75%, 50% et 25%. Ces prairies ont été pâturées en rotation par des troupeaux d'agneaux entre 2008 et 2010. La production annuelle totale en matière sèche (MS) (kg/ha) a été réduite chaque année en diminuant les niveaux d'irrigation (P<0.01). Ainsi, la moyenne de production en matière sèche était de l'ordre de 9,59, 8,78, 7,21 et 4,86 t/ha pour la capacité au champ de 100%, 75%, 50% et 25%, respectivement. Les pairies irriguées à capacité au champ de 100% et de 75% fournissent une production animale équivalente. Cependant, le gain en poids vif GPV/ha est diminué (P<0.01) quand les pâturages sont irrigués a une capacité au champ de 50% ou a un niveau inferieur.*

Mots-clés. *Production de pâturages – Déficit d'irrigation – Pâturage – Efficacité d'irrigation – Production ovine.*

I – Introduction

The erratic and low precipitation often causes feed shortages and variations in forage production in most dry areas (Ates *et al.,* 2010). Irrigation can increase reliability and pasture persistence to attain desirable forage and animal production (Jensen *et al.,* 2001). However, animal production that relies on irrigated pastures is subject to water scarcity the same as irrigated field crops in dry areas. Thus, low water resources force farmers to grow more with less water (Postel, 1998). Nevertheless, the highest amount of water required for optimal crop production has been recorded in Turkey, Egypt, India, Pakistan, Iraq and Uzbekistan, reflecting the ineffective use of irrigation in these countries (Doell and Siebert, 2002). The negative impact of this inefficient use of scarce water resources on agricultural production and the environment is projected to be exacerbated by climate change (IPCC, 2007). Deficit irrigation has been promoted as one of the primary means of increasing efficiency of production and coping with scarce water resources (Oweis and Hachum, 2008). Thus, this study evaluated the impact of strategic use of deficit irrigation on animal production, in permanent pastures.

II – Materials and methods

The study was conducted in Bahri Dagdas International Agricultural Research Institute (37° 51' N, 32° 33' E, 1008 m a.s.l.), Konya, the Central Anatolia Region of Turkey. The soil is a clay-loam with slightly alkaline characteristics. The climate is continental type with mean temperatures of -0.3°C min and 23.6°C max and total annual precipitation of 322 mm. A pasture seed mixture of *Trifolium repens* (3 kg/ha), *Lotus corniculatus* (3 kg/ha), *Festuca rubra* (9 kg/ha), *Poa pratensis* (5 kg/ha) and *Lolium perenne* (6 kg/ha) was sown in 0.2 m row spacing on 4 April 2007. N-P fertilizer, 100 kg/ha N and 100 kg/ha P_2O_5, was uniformly applied at sowing and repeated in October 2008 and 2009. The paddock was divided into three blocks, each containing four fenced plots (45 × 25 m) in March 2008. Each of these blocks represented one replicate of four individually grazed pasture treatments. Within each block the four irrigation treatments were designed to maintain the soil moisture at 100% (FC 100%), 75% (FC 75%), 50% (FC 50%) or 25% (FC 25%) of field capacity. Irrigation treatments began in April 2008. No irrigation was applied during the late autumn-winter periods. The irrigation schedule was designed around daily monitored soil tensiometers placed to 0-30 and 30-60 cm depths in FC 100% plots and gravimetric soil moisture measurements. Water was applied to each treatment as required to maintain the prescribed FC% on each occasion. Total precipitation and supplementary irrigation throughout the experiment are given in Table 1.

Table 1. The amount of total and supplementary irrigation in pastures irrigated to 100, 75, 50, 25% of field capacity (FC) in Konya, Central Anatolia in 2008, 2009 and 2010

Level of irrigation	Supplementary irrigation (mm)			Total irrigation (mm) (precipitation + irrigation)		
	2008	2009	2010	2008	2009	2010
FC 100%	867	760	816	1122	1170	1102
FC 75%	650	570	612	905	980	898
FC 50%	433	380	408	688	790	694
FC 25%	217	190	204	472	600	490

Konya merino weaned lambs were stratified according to their liveweights (mean LW=41±2.6 kg in 2008, 43±1.8 kg in 2009 and 39± 1.3 kg in 2010) and allocated randomly to treatment groups. All treatments were rotationally grazed with one flock of sheep grazing one plot and the other two plots spelled. The rotation length was about 20 days with an average grazing duration of 8-12 days. The average grazing intensity with FC 100%, 75%, 50% and 25% was 107, 89, 62 and 45 lambs/ha respectively. In each year, grazing began on 24 April for each treatment and ended on 20 October. Dry matter production (DMP, kg DM/ha) from each treatment was measured by quadrat cuts. Samples from the quadrat cuts were dried in an oven (65°C) until constant weight. Live weight gain per hectare (LWG, kg DM/ha) was determined by weighing the lambs prior to and after each grazing period. LWG was calculated by multiplying LWG/head by the number of lambs/ha. Total annual DMP (kg DM/ha) and LWP (live weight production, kg/ha/d) were analyzed by ANOVA with three replicates for each measurement period as a randomized complete block design. However the LWG (g/head/d) was analysed using a completely randomized design model. The data were analyzed by analyses of variance (ANOVA) of unbalanced design (due to differences in the number of lambs per treatment) with repeated measures for each LWG measurement period. This was due to the fact that blocks were no more segregated since they were rotationally grazed with the same flock. It was assumed that the pooled data from the three replicates were random samples within the same population of lamb grazing under a given irrigation level. The interaction between irrigation level and grazing period was analyzed using repeated measures under a completely randomized design model. Significant differences among treatments means were compared by Fisher's protected LSD at $\alpha=0.05$. All analyses were done using Genstat version 8.1 (GenStat, 2005).

III – Results and discussion

The highest DMP (kg/ha/y) was obtained from the pastures irrigated at FC 100% in each year. DMP (kg/ha/y) of pastures were reduced ($P<0.01$) by at each decreasing level of irrigation to an extent by 50% lower production from pastures irrigated at FC 25% compared to pastures irrigated at FC100% (Table 2).

Table 2. Annual dry matter (kg DM/ha) and mean liveweight production (kg/ha/d) from pastures irrigated to 100, 75, 50 and 25% of field capacity (FC) in Konya, Central Anatolia

Production	Year	Level of irrigation				SEM	P	LSD
		FC 25%	FC 50%	FC 75%	FC 100%			
DMP (kg DM/ha/y)	2008	4069d	7117c	8733b	9665a	233	0.01	806
	2009	5724d	7058c	9055b	9801a	298	0.01	1031
	2010	4774d	7457c	8572b	9311a	155	0.01	537
LWP (kg/ha/d)	2008	0.87c	1.67b	1.93ab	2.14a	0.21	0.01	0.36
	2009	0.95c	1.74b	1.97ab	2.24a	0.16	0.01	0.32
	2010	0.92c	1.87b	2.27a	2.54a	0.13	0.01	0.38

LWG per lamb (g/day) did not differ ($P=0.35$) among irrigation treatments in 2008, 2009 and 2010 (Fig. 1 a, b, c). However, the LW gains of animals were affected ($P<0.01$) by seasonal shifts with the lambs growing the fastest in the spring the slowest in summer. Over three years, LWG per hectare of pastures irrigated to FC 100% gave over 2 kg/ha/d (Table 2). This was similar to the LWG per hectare obtained from pastures irrigated to FC 75% that ranged between 1.9 and 2.3 kg/ha/d. The lower levels of irrigation resulted in reductions ($P<0.01$) in LWGs. Average total annual animal LW production was 198, 380, 445 and 498 kg/ha for FC 25%, 50%, 75% and 100% respectively. Over three years, LWP was the most consistent in the spring and the early summer and averaged over treatments and years, these months accounted for 51% of total annual LWP. In general, supplemental irrigation during the summer and the autumn months could not provide as high LWGs of weaned lambs as in the spring period even at the FC 100% and 75% levels. This was probably due to the slower growth of the new plant tissues and the lower nutritive values of these grasses which typically occur at high and low air and soil temperatures (Waghorn and Clark, 2004).

The irrigation efficiency (a unit of water to produce a unit of LW) was reduced dramatically during summer (Fig. 2). This situation questions the benefit of applying high amounts of water to pastures in dry areas during the summer months when the efficiency of irrigation is low (Moot *et al.*, 2008). The focus of production should be on lamb fattening in spring while managing pastures for the maintenance of dry ewes, and using a lower amount of water during the summer period when the water use efficiency of plants is low due to high soil evaporation and high night time temperatures (Moot *et al.*, 2008). Deficit irrigation between 50% and 75% FC may also be used in spring when evapotranspiration rates are lowest. The Inclusion of annual legumes to pasture mixtures may help improving the efficiency of water use in sown pastures. It was reported in Australia where the total water use of pastures containing annual clovers was substantially lower than for perennial pastures as irrigation was not applied during the summer months when evaporation was high, although overall production was lower than for pastures established with perennial species (Stockdale, 1983). Annual legumes in permanent dryland pastures can also promote high lamb growth rates in early spring when they have high dry matter production due to their lower temperature requirements compared with perennial legumes (Ates *et al*., 2010).

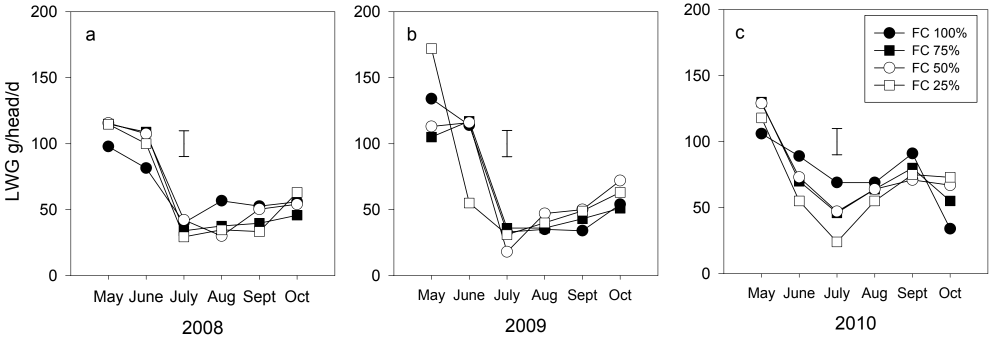

Fig. 1. Liveweight gain per head (g/head/d) in (a) 2008 (b) 2009 and (c) 2010 from pastures irrigated to 100, 75, 50 and 25% of field capacity (FC) in Konya, Central Anatolia. Bars represent SEM.

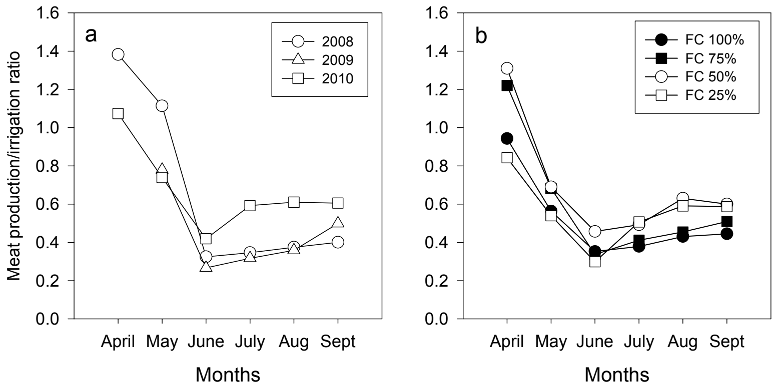

Fig. 2. The efficiency of irrigation per unit of meat produced (kg/ha-cm): (a) in 2008, 2009 and 2010, (b) from pastures irrigated to 100, 75, 50, 25% of field capacity (FC) in Konya, Central Anatolia.

IV – Conclusions

Lamb production (kg/ha) in the spring and early summer was the most consistent and thus the focus should be on fattening lambs during these periods. The irrigation efficiency (units of water to produce a unit of forage to produce a unit of LW) was low during summer months. Including annual legumes that commence growth earlier in spring than perennial legumes to pasture combinations in dry areas may provide higher water use efficiency.

References

Ates S., Tongel M.O. and Moot D.J., 2010. Annual herbage production increased when sub clover overdrilled into grass-dominant dryland pastures. In*: Proc. of the New Zealand Grassland Assoc.*, 72, p. 3-10.

Doell P. and Siebert S., 2002. Global modeling of irrigation water requirements. In: *Water Resources Research*, 38, p. 1010-38.

GenStat, 2005. The Guide to GenStat Release 8.1 Part 2: Statistics. In: Payne, R.W. (Ed.). Lawes Agricultural Trust (Rothamsted Experimental Station). VSN International, Oxford.

IPCC, 2007. *Climate change 2007. Impacts, adaptation and vulnerability*. Contribution of working group II to the IV Assessment Report.

Jensen K.B., Asay K.H. and Waldron B.L., 2001. Dry matter production of orchardgrass and perennial ryegrass at five irrigation levels. In: *Crop Sci.*, 41, p. 479-487.

Moot D.J., Brown H.E., Pollock K. and Mills A., 2008. Yield and water use of temperate pastures in summer dry conditions. In: *Proceedings of New Zealand Grassland Assoc.* 70, p. 51-59.

Oweis T. and Hachum A., 2008. Optimizing supplemental Irrigation: Tradeoffs between profitability and sustainability. In: *Agricultural Water Management*, 96, p. 511-516.

Postel S., 1998. Water for Food Production: Will There Be Enough in 2025? In: *Bioscience*, 48, p. 629-637.

Stockdale C.R., 1983. Irrigated pasture productivity and its variability in the Shepparton region of northern Victoria. In: *Australian Journal of Experimental Agriculture and Animal Husbandry*, 23, p. 131-139.

Waghorn G.C. and Clark D.A., 2004. Feeding value of pastures for ruminants. In: *New Zealand Veterinary Journal,* 52, p. 320-331.