Original Research Article

Optimization of Water Productive by Conjunctive use of Borewell and Canal Water to Improve Productivity of Sheep in Arid Climate

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ABSTRACT

Water productivity is crucial in arid regions like Rajasthan due to limited water availability and climate variability. Ensuring sustainable agriculture and livestock production under these challenging conditions requires careful management of available water sources. This study aims to evaluate the impact of using fresh canal water, saline borewell water and combination of both in 50:50 ratio to address problem of water scarcity and salinity issues on production performance of sheep.

The experiment involved eighteen healthy lambs, aged 2-3 months, managed intensively and divided into three groups of six lambs each based on a randomized block design. All groups were fed (*Pennisetum glaucum*) and lucerne (*Medicago sativa*) *ad libitum*, along with concentrates as adjusted accordingly to their body weights. The groups were given different drinking water: canal water (G1), conjunctive canal and borewell water (G2), and borewell water (G3) in a clean bucket twice daily. Over four weeks, the study assessed the production performance and water productivity in relation to sheep production. Total feed intake and bodyweight were not affected significantly between the groups by various drinking water sources. The average total water consumption varied significantly different and was higher 81.6 ± 1.91 liter for group 3 offered borewell drinking water compared to group 1 and 2 had similar values (74.4 ± 1.84 liter). The results revealed the highest water productivity in the canal water (5,771.34 liter), followed by conjunctive water (6,129.00 liter), and the lowest in the borewell water (6,312.00 liter) per kilogram of weight gain. These findings are significant for sustainable agricultural and livestock practices in arid regions, where optimizing productivity with limited water resources is essential for food security and improving livelihoods of farmers.

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Keywords: Water productivity, Sheep, Arid regions, Conjunctive use, Borewell and Canal Water

1. INTRODUCTION

Arid and semi-arid regions of Rajasthan face increasing challenges in agriculture and livestock sustainability due to escalating water scarcity exacerbated by climate change. Continuously excessive groundwater extraction and reduced rainfall have led to increased problem of water crises and salinity in both water and soil. The state has minimal surface water resources, comprising just 1.16% of the nation's total water reservoirs. The water crisis has reached a critical stage, where only 30 out of 299 blocks (12%) classified as safe (Kumar P ,2020). Efficient water management and enhancing water productivity measured as the yield per unit of water used are crucial to ensuring food security and economic stability under challenging environmental conditions.

Agriculture and livestock production play a vital role in food security but utilize over 80% of freshwater resources, with around one-third allocated to animal production (Hoekstra and Meconnen, 2012). Small livestock farming is particularly important for poor rural households in India, where income from livestock constitutes a significant portion of total earnings. Though among livestock, sheep are particularly resilient to drought stress and are efficient utilizer of water and scarce desert feed resources of arid regions (Joshi *et al.* 2024). The ability of animals to tolerate saline water depends on factors like species, salinity levels, and the types of salts and minerals present. Some studies indicate that low salinity levels may improve animal performance, but higher salinity levels can reduce it (Costa *et al*., 2013). However, salinity of water negatively affects livestock's water intake, feed consumption, health, and productivity (NRC, 2007). Goat and sheep show higher tolerance to salinity of drinking water as compared to other ruminants and kids can tolerate the water salinity up to 6000 ppm without negatively affecting the production performance (Harini *et al.* (2022)). Even though, water with electric conductivity (salt content) from 8.0-11.0 Ds/m is optimum for goat.

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The ground water (borewell water) varies highly in the type and contents of dissolved solids. Understanding of overall water productivity is essential due to address the challenges of achieving higher productivity and resource-use efficiency, especially when surface water resources are scarce and available groundwater is often saline, the conjunctive use of both could be a viable alternative. By evaluating performance responses of sheep to water use, the study aims to identify optimal water management practices that maximize production performance under varying water availability conditions. Such insights are essential for sustainable livestock development in arid regions.

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2. MATERIALS AND METHODS

The feeding trial was conducted in August 2023 over a 22-day period, with feeding managed on a group basis in a semi-open shed. Housing space was provided according to BIS specifications at ICAR – CSWRI – Arid Region Campus, Bikaner. During the study, temperatures ranged from a high of 36.1°C to a low of 25.4°C, with humidity levels varying between 76.7% and 47.3%. Wind velocity was recorded at 10 km/h. Eighteen healthy lambs, both males and females were randomly assigned to three experimental groups, each containing six lambs following a randomized block design (RBD) with similar initial average body weights. The lambs were vaccinated according to a set schedule and regularly monitored for external and internal parasitic infestations, with preventive and curative measures taken as needed.
All groups were fed a basal diet consisting of ad-lib dry bajra fodder, concentrate and green lucerne fodder, provided in the morning and evening according to their requirements. The drinking water source varied for each group: G1 received canal water, G2 received a 50:50 mixture of canal and borewell water, and G3 received borewell water. Water was provided in clean buckets twice daily, in the morning and evening. The feed and water intake of each group was recorded separately each morning and evening. Leftover roughage was weighed, and feed intake was calculated by difference. The lambs' bodyweights were measured weekly before feeding and watering, and average daily weight gain (g/day) was calculated by difference. Each lamb was provided 2 liters of water per day, and any leftover water was measured to determine individual water intake. The water parameters tested using the Multi-Parameter Water Analyzer-371, Systronics, included temperature, pH, and electrical conductivity (ECw, in dS/m). The virtual water requirement was calculated by summing the water used for producing the fodder consumed by the animals and the water directly used for drinking. An Analysis of Variance (ANOVA) was performed using statistical software to assess the significance of differences between treatments.

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3 RESULTS AND DISCUSSION

Small ruminants are raised by two third of rural population mainly for wool, meat and milk purposes. Mutton contributes 70-80 % earning of sheep farmers. The amount of meat produced in India is eight highest in the world (FAO, 2014). The total meat production in Rajasthan is 240.28 thousand tones for the year 22-23 with an annual growth rate of 8.92. The demand of animal products is increasing at faster rate due to population growth, change in feeding habits and economy. Globally livestock feed and fodder cultivation are one of the major causes for water depletion (Saini *et al.* 2024). Considering the predicted increase in water scarcity and salinity in the future, it is necessary to identify the requirement of water for production of per kg gain in sheep farming under varying water sources. To evaluate the performance, changes in water intake and loss, feed intake, body weight are commonly studied variables. Therefore, in present study, the performance parameters that can be influenced by salinity of drinking water were examined and the results were presented in Table 2.

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3.1 Water characteristics

The salinity status of canal water, mix water in 50% ratio and borewell water was measured before, during, and after the feeding trial as electrical conductivity (EC) showed values averaging 0.75 ds/m, 2.25 ds/m and 4.85 ds/m respectively for canal, mix and borewell water. Salinity or dissolved solids indicate suitability and palatability of water for livestock. In borewell water, the EC value is found to be very high in comparison to canal water and mix borewell and canal water. It indicates that the ground water is moderately saline. The pH measurement values ranged between 7.90-8.00 indicate alkalinity nature of the water. The saline water containing high concentrations of minerals mainly sodium chloride largely affects the livestock productive aspects.

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Table 1: - Chemical composition of water offered to lambs

Water quality	pH	ECw (ds/m)	SAR (meq/L)	Cations Na^+ (meq/L)
G1 (canal water)	7.90	0.75	4.56	2.10
G2(conjunctive water)	7.94	2.25	7.20	11.20
G3 (borewell water)	8.00	4.85	10.02	14.20

Table 2: - Feed and drinking water intake and estimated virtual water requirement per kg gain

Groups (n=6)	G1	G2	G3
Body weight changes			
Total B. Wt. gain (kg)	2.12±0.03	2.10±0.05	2.09±0.05
ADG (g/d)	96.36±1.72	95.75±2.46	94.99±2.28
Avg. feed intake (kg/d)			
Morning feed intake	1.48±0.11	1.47±0.08	1.29±0.33
Evening feed intake	1.68±0.62	1.77±0.64	1.78±0.61
Concentrate intake	0.84±0.017	0.85±0.017	0.83±0.009
Total feed intake	4.00±0.25	4.10±0.26	3.90±0.7
Avg. water intake (l/d)			
Morning water intake	5.40±0.20	5.63±0.12	5.88±0.18
Evening water intake*	7.00±0.13	6.77±0.33	7.73±0.16
Total water intake*	12.40±0.30	12.4±0.41	13.61±0.32
Estimated virtual water requirement for per kg gain in lambs' production			
Average water intake (litre)*	74.4 ± 1.84	74.4± 2.48	81.6 ± 1.91
Average Virtual water intake/kg gain	5771.34± 431.04	6129 ± 1117.37	6312± 1056.90
Average Virtual water intake/kg protein	23085.36	24516.00	25248.00

Level of significance p <0.05

3.2 Body Weight (kg)

The mean initial body weight of lambs during study periods was 17.31±1.60,17.00±1.30 and 17.83 ± 0.30 kg and final bodyweight was 19.43±1.60,19.10 ±1.28 and 19.85±0.40 kg respectively in group G1,

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G2 and G3. The influence of water salinity did not have a significant effect on weight gain in the all-groups lambs. Higher total gain (2.12 ± 0.03 kg) and average daily gain (96.36±1.72 kg) were observed for G1 offered canal water for drinking and lower weight gain reported in G3 lambs which consumed borewell water. This conforms previous studies that did not find any effect of drinking water salinity on ADG in the kids (Harini et al 2022, El-Gawad 1997). In our study, no reduction in DMI of lambs provided with saline waters could be the possible reason for non-significant differences in bodyweight gain among various groups under study. Zoidis, E. and Hadjigeorgiou (2017) reported that the live body weight of goats was not affected by increasing NaCl concentration; however, there was a slight tendency decrease in bodyweight at the highest (20%) salt concentration.

3.3 Feed Intake (kg/day)

Total feed intake was not affected significantly between the groups by various drinking water sources. Overall, the lambs in group 3 offered borewell drinking water had consumed comparatively low feed (3.90±0.7 kg/day) in comparison to other groups. Groups 2 and 1 lamb offered canal and conjunctive water had similar feed intake (4.0±0.26 kg/ /day). This aligns with the studies that feed intake was not affected significantly by salinity of water in sheep (Yousfi et.al.,2016, Assad et al 1997).

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3.4 Water Intake (lit./day)

In contrast to feed intake, total consumption of water significantly affected by various drinking water regime among the groups. The results have shown significantly higher average water consumption in evening by the group 3 lambs provided borewell water compared to group 2 and group 1 lambs offered conjunctive water and canal water. The total water consumption (liters/day), G1 and G2 offered canal and conjunctive water exhibited a similar total water consumption of 12.40±0.82, which was significantly lower than the bore well water 13.61±0.64 observed in G3. The results of the present study showed higher drinking water intake in the lambs that were provided with saline borewell drinking water is similar to earlier reports (Eltayeb 2006, Runa *et al.* 2019), and it is the key physiological mechanism to decrease the high salt intake by excreting through urine. However, many other studies revealed that water consumption was decreased when the salt level is increased to 2 % (Zoidis, E. and Hadjigeorgiou ,2017)

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Evaluation of water requirement of fodder and per kg gain

The amount of water required to produce one kg of feed to estimate water productivity per kilogram of meat produced under experimental feeding regimes considered was 1.07 kg/m³ for lucerne and 1.57 kg/m³ for bajra fodder (Raj Bajra) and 2.35 for kg/m³ barley (Saini et al 2024). The average water consumption(liter) varied significantly between groups and was higher (81.6 ± 1.91) for group 3 offered borewell drinking water compared to group 1 and group 2 had similar values (74.4 ± 1.84). The virtual water requirement per kg gain that was assessed by both direct water intake from drinking and indirect water intake was observed superior in G1 lambs (5771.34 liter) followed by G2 (6129.00 liter) and G3 (6312.00 liter) per kilogram gain respectively. Thus, results have shown higher water productivity for canal water followed by conjunctive water and borewell water had lower productivity. The finding suggest that consuming canal water led to increased body weight gain while reducing water needs per kilogram of meat production. This, highlights the enhanced water productivity linked to canal water and a blend of canal and borewell water in Rajasthan's arid regions compared to the utilization of saline groundwater solely available for sheep farming.

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4. CONCLUSION

The study's finding indicates that canal water had higher water productivity as its consumption led to increased body weight gain while reducing water needs per kilogram of meat production. Borewell water resulted in lower water productivity, but its blending with canal water can enhance water productivity compared to the utilization of saline groundwater solely which is mainly available for sheep farming in Rajasthan's arid regions. Future research needed to evaluate the impact of different saline water levels and types of minerals in different livestock animal to compare the mechanism of action of each which will help in the future to maximize production performance under varying water availability conditions. Such insights are essential for sustainable livestock development in arid regions.

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