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Senthilkumar D
Assistant Professor, Livestock Farm Complex, Veterinary College and Research Institute, Tamil Nadu Veterinary and Animal Sciences University, Orathanadu, Tamil Nadu, India

Corresponding Author:
Senthilkumar D
Assistant Professor, Livestock Farm Complex, Veterinary College and Research Institute, Tamil Nadu Veterinary and Animal Sciences University, Orathanadu, Tamil Nadu, India

Evaluating secondary treated wastewater irrigation integrated with organic and inorganic nutrients for enhanced green fodder production in BAJRA NAPIER hybrid grass CO (BN)5: A study from Orathanadu, Cauvery Delta, Tamil Nadu

Senthilkumar D

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Abstract
This study evaluated the effects of secondary treated municipal wastewater (TWW), integrated with organic and inorganic nutrient sources, on the yield and nutritional quality of Bajra Napier hybrid grass (cv. CO(BN)5). A field experiment was conducted from 2018 to 2021 in Thanjavur, Tamil Nadu, using a strip plot design with four replications. Treatments consisted of five irrigation ratios combining TWW and groundwater, and four nutrient combinations of manure and NPK fertilizer. Results indicated that irrigation with TWW combined with fertilizers significantly increased total green and dry fodder yields. The highest green fodder yield (431.0 t ha^{-1} yr^{-1}) and dry fodder yield (76.7 t ha^{-1} yr^{-1}) were recorded in the treatment combining exclusive TWW irrigation with 100% inorganic nutrients (H5V1). This treatment also yielded the highest crude protein (13.53%) and the lowest crude fibre (28.03%) content. In contrast, the control treatment, which used groundwater irrigation without nutrient application, produced the lowest green and dry fodder yields (222.5 and 47.6 t ha^{-1} yr^{-1}, respectively). The findings demonstrate that integrating secondary treated wastewater with recommended nutrient applications is an effective strategy for enhancing both the yield and quality of Bajra Napier hybrid grass. This practice offers a sustainable approach to conserve groundwater resources while productively utilizing the nutrients present in wastewater for fodder cultivation.

Keywords: Bajra Napier hybrid grass, treated wastewater irrigation, green fodder yield, crude protein

1. Introduction
Agriculture and livestock production are inextricably intertwined, mutually dependent, and essential for total food security. In 2018-2019, livestock production contributed 4.4 per cent of the total national value added at current prices, making it the backbone of Indian agriculture (Department of Animal Husbandry & Dairying, 2019) [1]. India is the world's largest milk producer (198 million metric tones) however, per capita milk production is poor due to a massive shortage of feedstuffs. On a 2 per cent geographical area, the country houses 15 per cent of the world's livestock population, indicating the extent of livestock pressure on our resources compared to other countries. However, insufficient to meet the rising cattle population, only 8.4 million hectares of cultivated feed are available (Mohan *et al.*, 2017) [2]. Furthermore, only 40 per cent of the required green forage is available from diverse sources. Therefore, bridging this crater is a significant priority. On the other side, In agricultural sector is the largest water user in this country and the quantity of water allocated to irrigating is expected to fall by 10-15 per cent in the next two decades (Central Water Commission, 2019) [3]. The estimated utilizable water resources of the country are 1122 BCM per year, out of which the share of surface water and groundwater is 690 BCM (Central Ground Water Board, 2019) [4] and 432 BCM (Ministry of Water Resources, 2017) [5] per year, respectively. In 2050, a total of 1,180 BCM has been estimated as available water for a high projection scenario.

Out of which irrigation will be accounted for nearly 68% followed by domestic use (9.5%), industries (7%), power development (6%), and other activities claimed about (9.5%), including evaporation losses, environment and navigational requirements.

In India, this reduction is predicted to be 10-12 per cent in 2025, whereas overall water demand is expected to increase 22 per cent in 2025 and 32 per cent in 2050 (Amerasinghe *et al.*, 2013) [6]. As a result, the majority of wastewater (80%) is released into water bodies (rivers, lakes, and seas) with little or no treatment and only a small percentage (14% in Indonesia, 10 % in Philippines, 9% in India, and 4% in Vietnam) is treated mostly or partially (Water and Sanitation Program, 2016) [7] and discharged into environmental media. On the other hand, water contamination is a severe problem in emerging countries like India.

The demand for water to meet the needs of a home, industrial and other farm operations necessitates the regeneration of wastewater, a cost-effective and appealing alternative to irrigating crops in arid and semi-arid places to sustain productivity (Sharma *et al.*, 2014) [8]. As a result, water reclamation and reuse are the most effective technique for fulfilling present and future water demands. Therefore, the reuse of treated wastewater in agriculture for fodder crops appears viable in this changing water demand scenario. As a result, the current study was carried out to determine the effect of treated wastewater irrigation, manure and inorganic fertilizer on green fodder yield and proximate components of the Bajra Napier hybrid grass variety CO (BN)5 in the Cauvery Delta region of Orathanadu, Thanjavur.

2. Materials and Methods

2.5 Statistical analysis

All the data obtained from the treatment plots and proximate parameters analyzed in the lab were subjected to a statistical analysis using analysis of variance (ANOVA). The least significant difference (LSD) at the probability of 5 % (p<0.05) was performed to compare means using SPSS for Windows (Released version 26) according to the methods of Gomez and Gomez (1984) [9].

3. Results and Discussion

3.1 Green and dry fodder yield

The effect of treated wastewater and nutrient combination significantly (p<0.05) influenced Bajra Napier variety CO(BN)5 green and dry fodder yield. It is evident from increased biomass production in the total harvests of the crop (Figure.1). The treatment H_5V_1 (Irrigation with treated wastewater alone + 100% inorganic nutrients) produced the highest total green fodder yield at (431 t ha^{-1} yr^{-1}) and followed by H_4V_1 (One irrigation with groundwater and two irrigation with treated wastewater irrigation + 100% inorganic nutrients) which recorded the green fodder yield of (417 t ha^{-1} yr^{-1}). Whereas the lowest total green fodder yield of about (222 t ha^{-1} yr^{-1}) was observed in control (H_1V_4-Irrigation with groundwater (GW) alone + without nutrients). In barley crop, Al-Karaki (2011) [10] reported the effect of irrigation with tertiary sewage treated water on yields and discovered a significant improvement in green fodder yields. The increased yield might be due to the continuous application of sewage water which supplies a small quantity of NPK nutrients for crop growth and it increased the yield of the Bajra Napier fodder crop (Srinivas *et al.*, 2014) [11]. These findings align with what has previously been published by Alghobar and Suresha (2016) [12], GhassemiSahebi *et al.* (2020) [13], and Nogueira *et al.* (2013) [14].

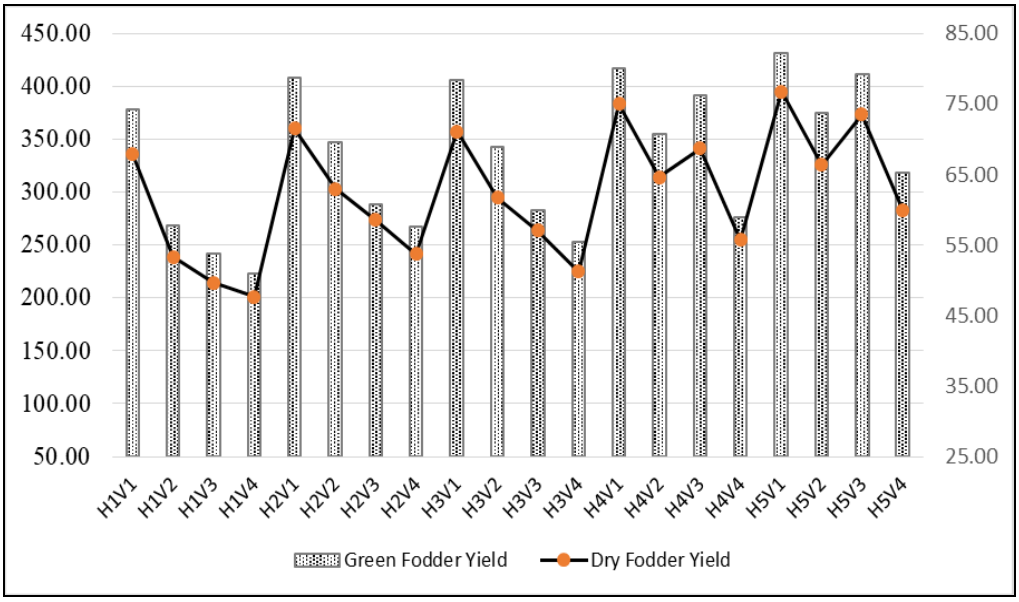

Fig 1: Effect of treated wastewater irrigation, manure and inorganic nutrients on average green and dry fodder yield (t ha^{-1} yr^{-1}) of Bajra Napier hybrid grass

A similar trend was seen in dry fodder yield also. The dry fodder yields (total of all cuts) expressed significant differences by using treated wastewater for irrigation along with manure and inorganic nutrients. Among the different treatments, the treatment irrigation with treated wastewater alone + 100% inorganic nutrients (H_5V_1) recorded the highest total dry fodder yield of 76.7 t ha^{-1} yr^{-1}, followed by one irrigation with groundwater and two irrigation with treated wastewater irrigation + 100% inorganic nutrients (H_4V_1) of 75.0 t ha^{-1} yr^{-1} and which is on par with alternate irrigation with groundwater and treated wastewater irrigation + 100% inorganic nutrients (H_2V_1), (Figure 1). On the other hand, the lowest total dry fodder yield was registered in control (H_1V_4) irrigated with groundwater alone without nutrients (47.6 t ha^{-1} yr^{-1}). Thus, the dry matter obtained from all treatments reflected its moisture content in conversion from green fodder

yield. The increases might be due to the decomposition of organic manure being accompanied by a release of appreciable quantity of nutrients and higher mineralization of full dose of fertilizer which contributes to higher total dry fodder yield. Finding on dry fodder yield under-treated wastewater with manure and fertilizer matches with the results of studies by Bharadwaj and Omanwar (1994) [15], Larson (2010) [16], and Raveena *et al*. (2021) [17].

3.2.1 Crude protein content

In general, adopting irrigation with treated wastewater and the recommended dose of organic and inorganic nutrients have substantially increased the crude protein content from 13.53-9.58 per cent of Bajra Napier hybrid grass compared to control irrigating with groundwater alone and without nutrients. Among the treatments, irrigation with treated wastewater alone + 100% inorganic nutrients (H_5V_1) recorded the highest crude protein content of about 13.53 per cent, followed by one irrigation with groundwater and two irrigation with treated wastewater irrigation + 100% inorganic nutrients (H_4V_1) of 13.46 per cent. Among the treatments tested, control (H_1V_4-irrigated with groundwater alone without nutrients) had the lowest crude protein content of 9.58 per cent. On the other hand, the highest crude protein content in fodder sorghum was in sewage irrigation (Soni *et al.*, 2016) [18]. It could be because numerous nutrients, particularly nitrogen, are required for plant protein synthesis in treated wastewater. Several studies have reported a significant increase in crude protein content of sorghum, maize and tomatoes through the application of treated wastewater (Ghanbari *et al.*, 2007 [19]; Galavi *et al.*, 2010 [20]; Orlofsky *et al.*, 2016 [21]).

3.2.2 Crude fibre content

The application of treated wastewater, manure, and inorganic nutrients significantly impact the crude fibre content of the Bajra Napier hybrid grass. Among the treatments in Fig. 2, the lowest crude fibre was recorded, 28.03 per cent in irrigation with treated wastewater alone + 100% inorganic nutrients (H_5V_1), followed by 28.18 per cent in one irrigation with groundwater and two irrigation with treated wastewater irrigation + 100% inorganic nutrients (H_4V_1). On the other hand, the highest crude fibre content was recorded in control (H_1V_4-irrigated with groundwater alone without nutrients) of about 31.18 per cent. The value of crude fibre is an indirect indication of the digestibility of the forage. It is known that the higher crude fibre content lowers the digestibility and vice-versa. The lower fibre content in treated wastewater and inorganic nutrition applied treatment compared to the control could be due to the supply of sufficient essential nutrients and better decomposition of organic matter improved the availability of nutrients resulting in high succulent biomass formation and yield (Srinivas *et al.*, 2014 [11]; Malarvizhi & Rajamannar, 2001 [22]; Sher *et al.*, 2016 [23]).

3.2.3 Total ash content

The total mineral content of a forage is called ash and it was determined by macro, micro and heavy metals. Among the treatments, the average total ash content was registered under implementing various combinations of treated wastewater and inorganic nutrients from 10.49 to 7.90 per cent. The highest average total ash content was recorded (10.49%) in irrigation with treated wastewater alone + 100% inorganic nutrients (H_5V_1) followed by one irrigation with groundwater and two irrigation with treated wastewater irrigation + 100% inorganic nutrients (H_4V_1). The 24.68 percentage was increased than the control. The increased NP fertilizer levels resulted in the highest total ash concentration (Ayub *et al.*, 2003 [24]; Mahmud *et al.*, 2003 [25]). Similar results were observed in the sorghum crop using treated wastewater irrigation and nitrogen (Galavi *et al.*, 2009 [26]; Kaur *et al.*, 2017 [27]).

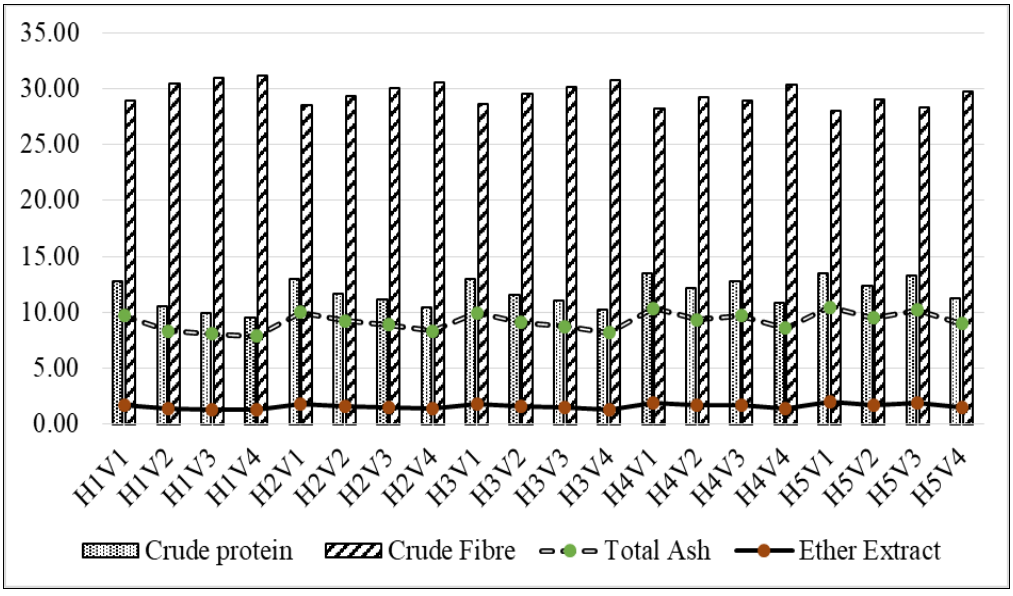

Fig 2: Average crude protein, crude fibre, total ash and ether extract (% per yr^{-1}) on the effect of treated wastewater irrigation, manure and inorganic nutrients of Bajra Napier hybrid grass

3.2.4. Ether extract content

Ether extract estimation refers to the calorific value of fodder. The treated wastewater irrigation and inorganic nutrients had significant differences in ether extract of Bajra Napier hybrid grass. The treatment irrigated with treated wastewater alone + 100% inorganic nutrients had the highest ether extract of 2.03 per cent, followed by 1.97 per cent in one irrigation with groundwater and two irrigation with treated wastewater irrigation + 100% inorganic nutrients. The control (H_1V_4-irrigated with groundwater alone without nutrients) had the lowest total ether extract content of 1.27 per cent. Studies showed that the content of ether extracts increased with the

addition of N (Vuckovic *et al.*, 2005) [28]. These results were on par with sorghum (Sher *et al.*, 2016) [23] and Bajra Napier (Kaur *et al.*, 2017) [27].

4. Conclusions

The current research found that the effect of treated wastewater irrigation combined with inorganic nutrients on Bajra Napier hybrid grass showed a significant difference in total green and dry fodder yield. In the proximate analysis, the imposed treatments influence crude protein, crude fibre, total ash, and ether extract. The treatment received irrigation with treated wastewater combined with organic and inorganic nutrients (RDF) registered the highest total green and dry fodder yield and had the positive response in proximate compounds. As a result, the Bajra Napier forage plants look vigorously and healthy compared to the control.

Based on the study results, it can be concluded that treated wastewater irrigation with the recommended dose of organic and inorganic nutrients is an available option to increase fodder productivity. Furthermore, it will help to effectively utilize nutrients available in treated wastewater, reduce the water demand for fodder cultivation, and conserve the groundwater in the future.

Conflict of Interest

Not available

Financial Support

Not available

Reference

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