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RESPONSE OF MULTI CUT FODDER SORGHUM WITH THE APPLICATION OF SOURCES OF IRRIGATION AND NUTRIENTS

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ABSTRACT

Multicut fodder sorghum Co (FS) 29 was evaluated for its growth and yield performance with the application of different sources of irrigation and nutrients. The experiment was conducted in split plot design with three replications. Main plot consists of treatments with application of irrigation through ground water (I_1), domestic sewage water (I_2) and ground and domestic sewage water alternatively (I_3). The sub plots consist of no fertilisers (control) (N_1), application of farm yard manure alone (FYM alone) (N_2), farmyard manure + NPK (FYM + NPK) (N_3) and NPK alone (N_4). The application of domestic sewage water along with FYM + NPK nutrients as per the treatment schedule resulted in higher plant height, leaf length, number of leaves, biomass production, dry matter and biomass yield of multicut fodder sorghum. However, pertaining to nutrient application, nitrogen uptake was higher with application of FYM +NPK but found on par with the application of NPK alone and application of FYM alone.

Keywords: Multicut fodder sorghum; growth; biomass yield; nitrogen use efficiency

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INTRODUCTION

In India, about 1,123 billion cubic metre of usable water resource is present and out of this, 433 BCM is ground water and 690 BCM is surface water. Natural rainfall contributes to about 68% of the country`s ground water. Agriculture is the major consumer of fresh water and almost 89% of ground water is extracted for agricultural use, 9% for domestic and 2% for other uses. Due to population growth and increase in water usage, water availability is found decreasing and has implications on agricultural sector. Hence, to cope with the increasing demand for water use, it is crucial to think on increasing water use efficiency of crops or cultivating drought tolerant crops or alternate sources of water other than fresh water or ground water.

Domestic sewage water can be considered as an alternative for fresh water

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as a source of water for irrigation. Increase in population has led to increased fresh water usage and thereby resulting in high output of domestic sewage water.

Expenses in disposal of domestic sewage water is enormous because of the higher cost involved in setting up of treatment plants (Rutkowski *et al.,* 2006). Domestic sewage water contains organic carbon, macro and micro nutrients, essential for crop cultivation, used for irrigation (Singh *et al.,* 2012), affecting the soil properties and nutrients carried through food chain.

In India, livestock population accounts 536.76 million numbers (20th Livestock census - 20th, 2019). The milk production is around 176.3 million tonnes and ranks first in the world. Dairy accounts for 5% of the national economy and provides employment for 80 million farmers. However, the average productivity is far less than the world`s average. This might be due to lesser availability of green fodder. In India, the fodder deficit is 11.24 %, 23.4 % and 28.9 % in dry fodder, green fodder and concentrates respectively (Roy *et al.*, 2019). The supply of fodder remains static due to declining land area under cultivation, unwillingness to diversify resources for fodder cultivation and not realising direct monetary benefit (Vennila *et al.,* 2019).

Water, being one of the major limiting factors for fodder cultivation, the use of domestic sewage water can be an alternative. Assefa *et al.* (2010), indicated that animals take up major nutrients required for animal growth, health and productivity through plants, because of which supplementing nutrients for crop growth is important. Hence, this study was conducted to evaluate the performance of an important multicut cereal fodder sorghum for its growth and yield production potential with application of different sources of irrigation water and nutrients.

MATERIALS AND METHODS

Location and design of experiment

The research was carried out over two years as pot culture experiment during 2019 and 2020 at the Madras Veterinary College campus located in the North Eastern region of Tamil Nadu, India. The soil is red soil with pH 7.00, electrical conductivity 1.12 mS cm^{-1}, organic matter 0.4%, N 287 kg ha^{-1}, P13 kg ha^{-1} and K 148 kg $ha^{-1}$and bulk density 1.4 g cm^{-3}. The climate in Chennai is tropical, hot throughout the year with the mean temperature of 38 to 42°C and an average rainfall of 943.7 mm and 987 mm during 2019 and 2020 respectively.

The domestic sewage water was collected from the Department of Dairy Science, at Madras Veterinary College. The sorghum variety Co (FS) 29, a variety from Tamil Nadu Agricultural University, sown in the pots and maintained as a perennial crop. The treatments were laid out in split plot design with three replications. The main plot treatments consist of application of irrigation through ground water (I_1), domestic sewage water (I_2) and ground and domestic sewage water alternatively (I_3). The sub plots consist of no fertilisers (control) (N_1), application of farm yard manure alone (FYM alone) (N_2), farmyard manure + NPK (FYM + NPK) (N_3) and NPK alone (N_4). The nutrients through organic and inorganic means were applied as per the treatment schedule. The recommended nutrient for multicut sorghum per hectare is 90:45:45 kg NPK along with 25 t of farm yard manure. Half the quantity of nitrogen through urea was applied as basal along with full quantity of phosphorus through single super phosphate and potassium through murate of potash. The calculated quantities of farm yard manure were applied as basal. The farm yard manure consists of 0.5 % N, 0.27 % P and 0.48 % K. Remaining half the quantity of nitrogen as urea was top dressed on 30thday after sowing. Sowing of sorghum was done in April, 2019 and grown in the pots for two years. The crop was harvested at regular intervals and allowed for ratooning by following the agronomic practices as per the crop production guide (Crop production guide, 2020). The first harvest of sorghum was done on 90 days after sowing and subsequently once in 60 days.

Plant sampling

Plant sampling was done at physiological maturity stage, for five consecutive plants in each pot and harvested from the base of the stem. Total number of leaves were counted, leaf length and leaf breadth were measured. Plant height (cm) was measured from the soil surface to the collar of the uppermost leaf. Leaf stem ratio was calculated by stripping off the leaves from the stem. Dry matter of the samples was done by drying the samples in hot air oven at 70 °C. The dry samples were subjected to chemical analysis to analyse the macro nutrient content. Fresh yield and dry yield of the crop was determined for each pot and extrapolated for one hectare. As the sorghum is a multicut crop, the harvest was done at stipulated time and maintained in the field for two years and the mean data collected for 14 harvests. The mean data was taken for statistical analysis.

The following equations were used to evaluate the N partitioning, translocation, and NUE (Koutroubas *et al*., 2020).

$$\text{Nitrogen uptake efficiency (kg ha}^{-1}\text{)} = \frac{\text{Nitrogen removed by plants (kg ha}^{-1}\text{) X 100}}{\text{Fertiliser N applied}}$$

$$\text{Biomass production efficiency (kg kg}^{-1}\text{)} = \frac{\text{Total above ground dry matter at maturity (kg ha}^{-1}\text{)}}{\text{N applied to the soil (kg ha}^{-1}\text{)}}$$

$$\text{Partial factor productivity} = \frac{\text{Nitrogen content of harvested portion of the crop (kg)}}{\text{Nitrogen applied (kg)}}$$

The results analysed with analysis of variance (ANOVA), regression and interpreted based on significance (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Application of different sources of irrigation water and nutrients had significant influence on the growth parameters of fodder sorghum (Table 1). The growth parameters such as plant height, number of tillers per m^2, leaf breadth was found significantly influenced by the application of FYM + NPK (N_3) and application of NPK alone (N_4) in all cuts and resulted in the highest average plant growth parameters. Similarly, the growth parameters increased significantly with the application of domestic sewage water (I_2), ground water and domestic sewage water alternatively (I_3). Plants irrigated with domestic sewage water had higher development rates in comparison with those irrigated with ground water suggesting the presence of nutrients and thereby resulting in increased plant height. This is similar to results reported by Parsons *et al.* (2010). The number of leaves per plant, leaf length and leaf breadth were found significantly influenced by the application of domestic sewage water and FYM + NPK (I_2N_3).

The application of domestic sewage water (I_2) and FYM+NPK (N_3) resulted in high biomass production, dry matter and greater yield compared to control (Table 2). Dry matter yield of fodder sorghum responded linearly to application of FYM+NPK (N_3) and was comparable with the application of NPK alone (N_4). Yield of fodder sorghum was enhanced positively by the addition of FYM+NPK (N_3). This might be due to the low concentration of heavy metal and availability of nutrients in domestic sewage water favouring the germination and growth of fodder sorghum (Walter *et al*., 2006). The favourable concentration of nutrients present in the domestic sewage water might be due to the fact that the sewage water collected was near the Department of dairy science, within the Madras Veterinary College campus and did not have any contaminants and the heavy metal concentration found in the domestic sewage water and was well within the limits. The concentrations of nutrients from the domestic sewage water and the applied nutrients had favourably resulted in increased growth parameters thereby increased the yield parameters and yield compared to control and application of ground water for irrigation. El-Nakhel *et al*. (2022) reported that the height of spinach at the time of harvest (30 DAS) was found significantly higher in the case of irrigation by DTSW and fresh spinach yield was observed to increase by 21.75 per cent over irrigation with well water. The presence of nutrients in domestic sewage water had positively influenced the availability of nutrients in the soil for the plant uptake and hence resulted in higher yield of fodder sorghum. This is in line with the findings of Parsons *et al*. (2010). The tillering ability on fodder sorghum is decided by the availability of nutrients and moisture. Hakeem *et al*. (2018), reported that the application of domestic sewage water for irrigation and nutrients helped in increased vegetative growth and thereby the capacity to produce more number of tillers.

The availability of nutrients from the domestic sewage water (I_2) and the application of FYM + NPK (N_3) might have resulted in the higher uptake of nutrients, resulting in rapid expansion of dark foliage. These foliage helps in increased photosynthesis by interception of solar radiation and eventually resulting in meristematic activity and increased leaf stem ratio of leaves of fodder sorghum. Galavi *et al*. (2009) also reported that the application of

Table 1. Effect of irrigation water and nutrients on the growth of multicut fodder sorghum

Treatments	Plant height (cm)	No. of leaves	Leaf breadth (cm)	Leaf stem ratio	No. of tillers per m^2
Irrigation					
I_1	229.9±2.25 b	91.38± 1.28 b	3.75 ± 0.21 b	0.230± 0.02 b	89.04 ± 1.59 b
I_2	243.0± 2.79 a	103.68 ± 1.92 a	4.10 ± 0.22 a	0.245 ± 0.28 a	92.87 ± 1.28 a
I_3	236.4 ± 1.75a	101.02 ± 3.64 a	3.92± 0.68 ab	0.239 ± 0.67 b	91.16 ± 1.67 ab
Significance	*	*	*	*	**
CV%	7.9	2.7	5.4	9.8	2.3
Nutrients					
N_1	203.6 ± 2.16 b	77.00 ± 1.68 d	3.49± 0.95 b	0.238 ± 0.08 d	84.44 ± 1.89 b
N_2	224.6± 3.58 b	94.06 ± 1.65c	3.73 ± 0.68 b	0.271 ± 0.36 b	88.40 ± 7.63 b
N_3	262.4±1.48 a	117.93 ± 2.28 a	4.51± 0.23 a	0.280 ± 0.42 a	96.69 ± 6.42 a
N_4	255.2 ± 2.86 a	105.82 ± 2.08 b	3.96 ± 0.56ab	0.265 ± 0.58 c	94.56 ± 7.65 a
Significance	*	*	*	*	*
CV%	6.6	6.7	12.4	11.1	3.5
I*N	**	**	*	*	**

Means with different letter(s) within column differ significantly

Table 2. Effect of irrigation water and nutrients on yield of multi cut fodder sorghum

Treatments	Total dry matter (kg ha^{-1} yr^{-1})	Total green fodder yield (kg ha^{-1} yr^{-1})	Average green fodder yield (kg ha^{-1})
Irrigation			
I_1	31.27 ± 2.16 b	125.08 ± 2.69 b	17.87 ± 1.76b
I_2	38.45 ± 3.12 a	153.81 ± 3.26 a	20.12 ± 2.12 a
I_3	32.52 ± 1.94 b	130.06 ± 2.68 b	18.29 ± 1.92b
Significance	*	*	**
CV%	10.1	10.1	3.5
Nutrients			
N_1	28.93 ± 0.98 c	115.72 ± 3.58 c	17.39 ± 1.96 b
N_2	31.74 ± 1.65b	130.97 ± 3.96b	17.71 ± 1.62b
N_3	36.58 ± 2.32a	146.30 ± 4.62 a	20.47 ± 2.78 a
N_4	32.74 ± 2.45b	126.94 ± 3.65 b	18.13 ± 4.93 b
Significance	**	**	*
CV%	6.2	6.2	8.1
I*N	*	*	*

Means with different letter(s) within column differ significantly domestic sewage water reduces the growth but when used along with application of nutrients enhances the biomass yield of fodder sorghum.

Mean uptake of nitrogen is influenced by the application of nutrients and not with the application of irrigation from different sources of water (Table 3). Nitrogen uptake was higher with application of FYM + NPK but found on par with the application of NPK alone and application of FYM. The uptake of nitrogen followed a linear response and was comparable with the application of NPK alone and FYM alone. However, application of NPK alone had significantly influenced the partial factor productivity compared to control and application of FYM alone and combination of FYM + NPK. Partial factor productivity decreased with application of nutrients. The biomass production efficiency of 1.98 kg kg^{-1} was achieved in pots without application of nutrients (control). The biomass production efficiency ranged from 1.25 kg kg^{-1} to 1.98 kg kg^{-1}. Nitrogen use efficiency showed a consistent result with the application of different sources of nutrients. Wang *et al.* (2022) reported that Nitrogen uptake from the soil and plant assimilation are essential for increasing nitrogen use efficiency in plants.

Nitrogen uptake in millets showed linear response with increased rate of N application (Heringer and Moojen, 2002). It is also noted that N uptake is dependent on water availability. The application of domestic sewage water helps in increasing water holding capacity and thereby increasing N uptake as given by Koutroubas *et al.* (2020). Recovery efficiency and N utilization is essential to understand the absorption capacity in fodder crops and if it exceeds the absorption capacity, it is lost or accumulated in plant tissues, thus affecting the conversion efficiency. Nitrogen uptake is important to understand the water flows from the soil to the root system and ion diffusion fluxes in the rhizosphere. Hence, in this present study the increase in uptake of nitrogen might be due to the increase in diffusion of nutrients for the plants. This is in accordance with the findings of Williams and Yanai, (1996).

Table 3. Response of multicut fodder sorghum (y) to nutrient application (x)

Nitrogen translocation traits	Regression equation	R^2	Model p
Nitrogen uptake (kg kg^{-1})	$y = 2.4551x + 61.26$	0.2441	0.103
Partial factor productivity	$y = 0.0273x + 0.666$	0.2219	0.122
Biomass production efficiency (kg kg^{-1})	$y = 0.0084x + 2.5808$	1	0.362

CONCLUSION

Application of domestic sewage water along with organic and inorganic nutrients enhanced the growth, yield and nutrient use efficiency of multicut fodder sorghum. This study concludes that domestic sewage water can be used as an alternative source of water for irrigation and does not possess any detrimental effect on perennial fodder crops.

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