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AGROMETEOROLOGICAL INDICES AND YIELD RESPONSE OF FODDER SORGHUM TO COMBINED USE OF SEWAGE SLUDGE, FYM, AND NITROGEN

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SUMMARY

A field experiment was conducted at Research Farm, Department of Agronomy, CCS Haryana Agricultural University, Hisar, Haryana, India during *kharif* 2023 and 2024 to assess the influence of sewage sludge, FYM and nitrogen on yield and agrometeorological indices of fodder sorghum. The experiment was laid out in split plot design with sewage sludge (2.5 and 5 t/ha) and FYM (2.5, 5 and 7.5 t/ha) in main plot, whereas, control, 50%, 75% and 100% recommended doses of nitrogen (RDN) in sub-plots with replicated thrice. Yield and agrometeorological indices *viz*. thermal use efficiency (TUE), photo thermal use efficiency (PTUE), helio-thermal use efficiency (HTUE) was significantly higher with the application of sewage sludge @ 5 t/ha and FYM @ 7.5 t/ha during both years. The 100% RDN treatment also showed significantly higher yield and agrometeorological indices *viz*. TUE, PTUE and HTUE during both years.

Key words: Agrometeorological indices, sorghum, fodder yield, TUE, PTUE, HTUE

Fodder sorghum (*Sorghum bicolor* L. Moench) is a key forage crop widely cultivated in tropical and subtropical regions, valued for its adaptability to adverse climatic conditions, rapid growth, and high biomass yield. Sorghum contains 8-10% crude protein, 60-65% neutral detergent fibre, 37-42% acid detergent fibre, 32% cellulose, and 21-23% hemicellulose. When harvested at 50% flowering stage or as single-cut fodder, sorghum genotypes provide 400-500 and 100-150 q ha^{-1} of superior green and dry fodder, respectively (Satpal *et al.*, 2020). Although India has 192.49 million cattle and 109.85 million buffalo, milk production is much lower than the world average. India now has a net shortfall of 11.24% green fodder, 23.40% dry fodder, and 28.90% concentrates (Raj *et al.*, 2024).

In regions like Haryana, where livestock farming plays a vital role in rural livelihoods, enhancing fodder productivity through sustainable practices is crucial. Sorghum crop can provide high tonnage of nutritive fodder with better resource management. Absence of improved genotype, weed control, plant protection, fertilizer and irrigation resulted in 39, 33, 31, 30 and 22 per cent losses in the productivity of fodder sorghum as compared to full package of practices (Satpal *et al*., 2021). For better nutrient management, one of the most promising approaches to achieve this through Integrated Nutrient Management (INM), which combines organic and inorganic nutrient sources to improve soil health and crop productivity. Among organic inputs, farmyard manure (FYM) and sewage sludge have gained attention for their ability to enhance soil structure, nutrient availability, and microbial activity. Sewage sludge, when treated and applied appropriately, can serve as a rich source of macro- and micronutrients, contributing significantly to plant growth and soil fertility (Kumar *et al.*, 2017). Similarly, FYM improves soil organic matter content and supports long-term nutrient cycling. When used in conjunction with nitrogen fertilizers, these amendments can synergistically improve nutrient uptake, plant vigor, and overall yield performance.

Agrometeorological indices serve as vital tools to evaluate crop responses under varying climatic conditions. These indices quantify the relationship between crop development and weather parameters, enabling a better understanding of how nutrient treatments interact with environmental factors to influence growth and yield. Integrating such indices into nutrient management research allows for more informed decision-making in climate-resilient agriculture.

Although the individual effects of organic and inorganic fertilizers on sorghum have been studied, limited research exists on their integrated application particularly the combined use of sewage sludge, FYM, and nitrogen and their influence on both yield and agrometeorological performance of fodder sorghum. This study aims to investigate the effect of integrated nutrient management involving sewage sludge, FYM, and nitrogen on the yield of fodder sorghum and associated agrometeorological indices. The outcomes are expected to provide a scientific basis for sustainable nutrient strategies that not only boost fodder productivity but also enhance environmental and agroclimatic resilience.

MATERIALS AND METHODS

The field experiment was conducted in the Research Farm, Department of Agronomy, CCS HAU, Hisar, situated in India's semi-arid, subtropical climatic zone at 29º 8'N latitude and 75º 70'E longitude, in the *kharif* seasons of 2023 and 2024. The elevation is 215.2 meters above the mean sea level. During the summer, the average monthly maximum temperature is from 43 to 45°C. The total rainfall and distribution in this region vary greatly. Between July and September, the South West monsoon contributes for 80-90 per cent of total rainfall. Weather data during crop experiment in 2023 and 2024 are presented in Figure 1 and 2. The experiment was conducted using split plot design, with sewage sludge (2.5 and 5 t/ha) and FYM (2.5, 5.0 and 7.5 t/ha) as the main factors. In subplots, four nitrogen levels (control, 50%, 75% and 100% RDN) were applied. All the treatments were replicated three times for statistical accuracy. Total weight of plants in each plot was recorded as biological yield and translated to quintals per hectare.

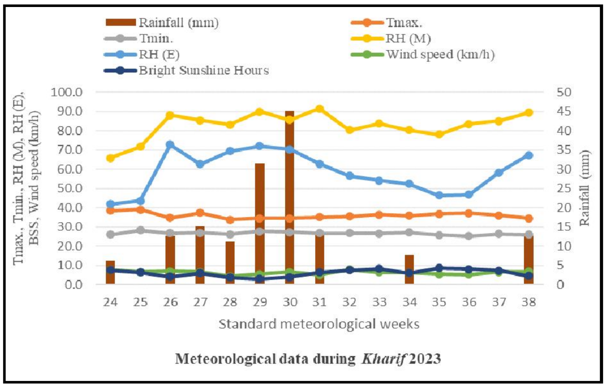

Fig. 1. Weekly meteorological data recorded during *Kharif* 2023.

Agro-meteorological indices

Growing degree days (GDD) (°C day): Growing degree-days from sowing to crop maturity/harvesting were intended by summing of daily mean temperature above base temperature (10°C) during the relevant time.

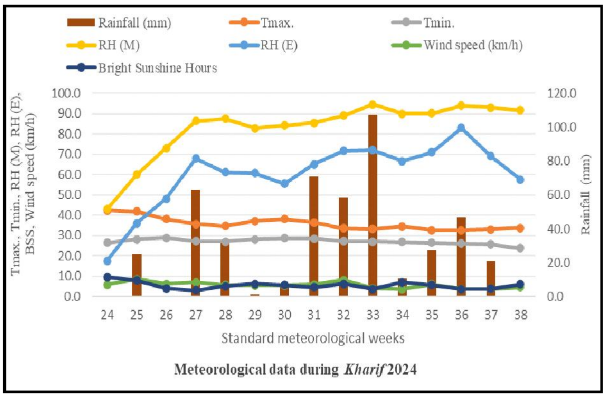

Fig. 2. Weekly meteorological data recorded during *Kharif* 2024.

$$GDD = \left(\frac{T_{max} + T_{min}}{2}\right) - T_b$$

Where, T_{max} and T_{min} are daily maximum and minimum temperature T_b is the base temperature

Photo thermal unit (PTU) (°C day hour): PTU for crop maturity was calculated by using formula:

PTU = GDD × maximum possible day length at the experiment site

Helio thermal unit (HTU) (°C day hour): HTU for crop maturity was calculated by using the formula:

HTU = GDD × Bright Sunshine hours

Thermal use efficiency (TUE) (kg ha^{-1} ºC day^{-1}): TUE for crop maturity was calculated by using the formula:

$$TUE = \frac{\text{Fodder yield (kg/ha)}}{\text{GDD (°C day)}}$$

Photo thermal use efficiency (PTUE) (kg ha^{-1} °C day^{-1}): PTUE for crop maturity was calculated by using the formula:

$$PTUE = \frac{\text{Fodder yield (kg/ha)}}{\text{PTU (°C day)}}$$

Helio thermal use efficiency (HTUE) (kg ha^{-1} °C day^{-1}): HTUE for crop maturity was calculated by using the formula:

$$HTUE = \frac{\text{Fodder yield (kg/ha)}}{\text{HTU (°C day)}}$$

The data was analyzed using OPSTAT, an online statistical analysis software (Sheoran *et al.*, 1998).

RESULTS AND DISCUSSION

Fodder yield

The influence of various nutrient treatments on fodder yield is presented in Fig. 3. The application of SS @ 5 t/ha produced the highest fodder yield (465.8 and 472.6 q ha^{-1}) during both years, which was significantly higher than that of SS @ 2.5 t/ha. Among the FYM levels, the application of FYM @ 7.5 t/ha resulted in significantly higher fodder yield (468.4 and 475.7 q ha^{-1}) during both years. The lowest fodder yield was observed under application of FYM @ 2.5 t/ha. Decomposition of organic manure in soil supplies nutrients throughout season and it helps in controlled release of nutrient through mineralization, which might have enabled better crop growth and production. Similar studies were observed by Sharma *et al.* (2015); Ankush *et al.* (2021). In case of nitrogen levels, significantly higher fodder yield (499.3 and 506.4 q ha^{-1}) was obtained with application of 100% RDN, compared to 75 and 50% RDN levels and lowest fodder yield (376.8 and 383.0 q ha^{-1}) was observed in control treatment during both the years of study. Nitrogen enhanced the merismatic activity, vegetative growth and photosynthetic activity. Cumulatively contributed to the greater green fodder output. Similar findings were also achieved by Mishra *et al.*, (2017); Chaudhary *et al.* (2018).

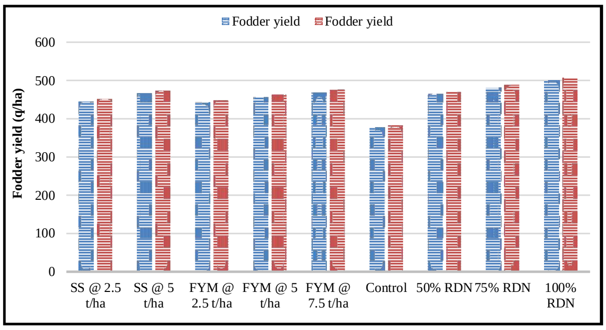

Fig. 3. Effect of sewage sludge, FYM and nitrogen levels on green fodder yield of sorghum.

Agro-meteorological parameters

Data related to various agrometeorological indices are given in Figure 4 and Table 3 during both growing seasons. During the crop growing seasons, GDD, PTU and HTU were 1941.1 (°C day), 25114.2 and 12078.5 (°C day hours), respectively during 2023 and during 2024, 1946.3 (°C day), 25227.1 and 9927.4 (°C day hours), respectively. Application of SS @ 5 t/ha observed significantly higher TUE, PTUE and HTUE over SS @ 2.5 t/ha treatment. This might be due to more availability of nutrients which increase biomass production and energy efficiency with higher dose of sewage sludge (Kumar *et al.*, 2022).

Among the FYM treatments, the application of FYM at 7.5 t/ha resulted in significantly higher TUE, PTUE and HTUE. This was followed by the treatments of 5 and 2.5 t/ha FYM. This might be due to more utilization of degree day as a heat unit concept of crop furthermore higher vegetative growth with increasing dose of FYM. Similar result was observed by Kumar and Kumar (2022).

In terms of nitrogen levels, there were notably higher TUE, PTUE, and HTUE values observed in the 100% RDN treatment, followed by the 75% and 50% RDN treatments. Higher dosages of nitrogen content improved vegetative growth, resulting in greater dry matter accumulation and ultimately higher yield. A similar finding was also achieved by Kumar and Kumar (2017).

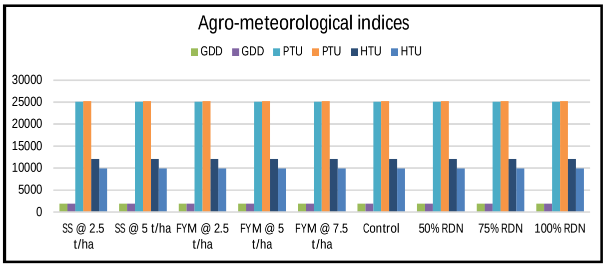

Fig. 4. Effect of sewage sludge, FYM and nitrogen levels on Agro-meteorological indices of fodder sorghum at 90 DAS (at harvest).

CONCLUSION

Based on two-year research findings, it was concluded that sewage sludge (5 t/ha), FYM (7.5 t/ha) and nitrogen (100% RDN) proved to be better in terms of fodder yield and agrometeorological indices of fodder sorghum. These results suggest that optimal levels of sewage sludge, FYM and nitrogen is most appropriate way to maintain the sustainability approach to crop management. Further research may explore

TABLE 1

Effect of sewage sludge (SS), FYM and nitrogen levels on Thermal use efficiency (TUE), Photo thermal use efficiency (PTUE), Helio thermal use efficiency (HTUE) of fodder sorghum

Treatments	Agrometeorological indices					
	2023			2024		
	TUE (kg ha^{-1} °Cday^{-1})	PTUE (kg ha^{-1} °Cday hr^{-1})	HTUE (kg ha^{-1} °Cday hr^{-1})	HUE (kg ha^{-1} °Cday hr^{-1})	PTUE (kg ha^{-1} °Cday hr^{-1})	HTUE (kg ha^{-1} °Cday hr^{-1})
Sewage sludge levels						
SS @ 2.5 t/ha	22.9	3.7	1.77	23.5	4.6	1.81
SS @ 5 t/ha	23.7	3.9	1.85	24.0	4.7	1.85
SE(m)±	0.09	0.01	0.007	0.08	0.02	0.006
CD @ 5%	0.3	0.04	0.021	0.2	0.04	0.019
FYM levels						
FYM @ 2.5 t/ha	22.8	3.7	1.76	23.1	4.5	1.79
FYM @ 5 t/ha	23.4	3.8	1.81	23.8	4.7	1.84
FYM @ 7.5 t/ha	24.1	3.9	1.86	24.3	4.8	1.88
SE(m)±	0.1	0.2	0.008	0.09	0.02	0.007
CD @ 5%	0.3	0.05	0.026	0.3	0.06	0.023
Nitrogen levels						
Control	19.4	3.1	1.50	19.8	3.9	1.53
50% RDN	23.9	3.8	1.85	23.9	4.7	1.84
75% RDN	24.7	4.0	1.91	25.2	4.9	1.85
100% RDN	25.7	4.1	1.98	26.1	5.1	2.01
SE(m)±	0.1	0.02	0.011	0.11	0.02	0.008
CD @ 5%	0.4	0.06	0.031	0.3	0.06	0.024

the long-term impacts of these treatments on changing environment through strategic nutrient management employing integrated input supply systems, all without destroying the soil's natural resource base.

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