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EFFECT OF LONG-TERM FERTILIZATION IN A SORGHUM-WHEAT CROPPING SEQUENCE ON DRY MATTER ACCUMULATION AND YIELD OF WHEAT IN VERTISOL

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ABSTRACT

In order to assess the effects of varying fertilizer application levels and INM on wheat productivity, a field experiment was carried out in 2023–2024 at the Research Farm, Department of Soil Science PGI, Dr. PDKV, Akola, under the Sorghum–Wheat cropping sequence in Black cotton soils of central India. The experiment included twelve treatments and was replicated four times in a randomized block design. RDF, FYM, and their combination were used as treatments starting in 1988. To evaluate the effect of nutrient management techniques, wheat's above-ground, below-ground, and total biomass as well as grain production were measured. When compared to chemical fertilization alone, the results showed that INM treatments, especially the combination of FYM and inorganic fertilizers, greatly increased biomass both above and below ground. Similarly, mixed organic and inorganic fertilizer sources produced the maximum total biomass and yield of wheat, indicating enhanced nutrient use efficiency and soil fertility restoration. The results show that long-term INM contributes to system sustainability in sorghum-wheat cropping sequences on Indian black cotton soils by maintaining wheat production and encouraging balanced biomass allocation.

Keywords **:** LTFE, INM, above and below ground biomass, wheat yield, correlation.

Introduction

Long-term fertilizer experiment recommendations have continued to play a significant role in the development of modern agriculture. According to Lopez-Bellido *et al.* (2001), the first consequence of such tests is unquestionably the possible increase in production that could be achieved as a result of the balanced usage of chemical fertilizers. Long-term studies yield important data for developing future plans to preserve soil health (Hati *et al.,* 2007). Long-term monitoring is necessary because changes in the characteristics, health, and nutrient supply capability of soil are gradual processes. Both identifying present soil changes and forecasting future ones are made possible by long-term monitoring (Antil & Singh, 2007).

About one-third of the world's population depends on wheat (*Triticum aestivum* L.), one of the most significant cereal crops in the world. It ranks second globally in terms of both area and productivity (Evans & Wardlaw 1996). In India, wheat grains constitute a somewhat superior source of protein. Wheat meets about 10–12% of the protein needs. In this endeavor, maintaining soil health and boosting output depend on the right ratio of inorganic fertilizer to organic manure (Kumar *et al.,* 2013).

In order to meet farmers' financial needs while also preserving favourable ecological conditions and assisting in the long-term restoration and maintenance of fertility and crop productivity, the combined use of concentrate organic materials and inorganic fertilizers

has drawn a lot of attention in the past (Kumar & Dey, 2007).

Vertisol pose a problem for nutrient management because of their high clay content and swelling and shrinking characteristics. The equilibrium of macro and micronutrients frequently determines the fertility of this soil, and how it reacts to fertilization techniques can change over time (Rathod *et al.,* 2025). In order to investigate the dynamics of biomass production and wheat productivity, the current field experiment was conducted to investigate the response of wheat to a continuous fertilization experiment in conjunction with FYM under the intense long-term sorghum-wheat cropping system. The outcome will be beneficial for growing in arid and semi-arid areas with comparable soil and climate conditions.

Material and Methods

Under the All India Coordinated Research Project on Long-Term Fertilizer Experiment (AICRP-LTFE), which was initiated in 1988-1989, a field experiment was carried out during the rabi season of 2023-24 at the Research farm, Department of Soil Science, Akola, Maharashtra. The purpose of the LTFE was to investigate the effects of integrated nutrient management on changes in crop productivity, sustainability, and quality under the sorghum-wheat cropping system. Vertisol, or black cotton soil, is the type of soil used in the experimental field.

Mineral fertilizers such diammonium phosphate, muriate of potash, urea, and single super phosphate were used to apply the nutrients. T_4 and T_9. Zinc was treated every two years using zinc sulphate for wheat solely (T_5), while S was applied annually for sorghum using gypsum (T_9). A month before the sorghum was planted, farmyard manure was applied once a year. For sorghum and wheat, the recommended fertilizer dosages were 100:50:40 and 120:60:60-kilogram N, P_2O_5, and K_2O ha^{-1}, respectively.

The biomass of wheat was quantified by measuring above- and below-ground components. Above-ground biomass was collected using a quadrat, cut close to the soil surface, oven-dried at 65 °C for 48 h (or until constant weight), cooled in a desiccator, and weighed. Below-ground biomass was obtained by excavating roots up to 30–100 cm depth, carefully washing to remove adhered soil, air-drying, followed by oven drying at 60 °C for 48 h, cooling in a desiccator, and recording dry weight. After harvest of wheat separate treatment wise grain yield was recorded.

Results and Discussion

Dynamics of Wheat biomass

The above ground biomass (AGB), below ground biomass (BGB) and total biomass was significantly affected by long-term manuring and fertilization. The highest AGB, BGB and total biomass was observed in the plots under 100% NPK + FYM @ 5 t ha^{-1} (T_8) and lowest under unfertilized control (Table 1 and Fig. 1). The AGB, BGB and total biomass contributed ranged from 0.44 to 0.71 Mg ha^{-1}, 0.21 to 0.49 Mg ha^{-1} and 0.65 to 1.2 Mg ha^{-1} respectively, in wheat.

Application of 100% NPK + FYM @ 5 t ha^{-1} (T_8) recorded the highest AGB (0.71 Mg ha^{-1}), BGB (0.49 Mg ha^{-1}) and total biomass (1.2 Mg ha^{-1}) indicating that the combined application of organic and inorganic fertilizers maximizes biomass production. The application of 75% NPK + 25% N through FYM (T_{11}) had significant above ground biomass (0.68 Mg ha^{-1}) and below ground biomass (0.47 Mg ha^{-1}), reinforcing the benefits of integrating FYM with NPK. 150% NPK) (T_3) followed closely with AGB, BGB and total biomass, suggesting that higher NPK rates enhance biomass.

Treatments T_8, T_{11}, and T_3 had significantly higher biomass values compared to the control (T_{12}). The control treatment (T_{12}) had the lowest AGB, BGB and total biomass, highlighting the importance of fertilization and manuring. The application of 50% NPK and 100% NP showed lower biomass of wheat, suggesting that reduced fertilization rates or omission of potassium affect dry matter accumulation biomass ultimately.

Treatments like T_8 and T_{11} showed the highest biomass accumulation due to the synergistic effects of combining FYM with NPK. Higher NPK rates exhibited higher biomass, suggesting that increased NPK rates support better plant growth. Micronutrient supplementation, addition of sulphur (T_9) and zinc (T_5) improved biomass production, highlighting the importance of micronutrients.

The improvement in AGB, BGB and biomass carbon with balanced fertilizer application along with FYM or organics was also reported by Meng *et al.* (2014) demonstrated that the application of manure leads to the formation of various organic carbon compounds from organic crop residues to humus. This process significantly increases root biomass and returns substantial quantities of carbon to the soil.

Fig. 1 : Variation in wheat biomass under different integrated nutrient management practices in a sorghum-wheat cropping sequence.

The average biomass yields of the treated plots were significantly higher than that of CK. The treatments NP, PK, NK, NPK and NPKM significantly increased the average biomass yields by 30–48%, without the marked differences between the years. Compared to CK, the average biomass of NPKM was the highest (94.06 t/ha), increased by 48.79%, but the average biomass yields of NP, PK and NPK were not significantly different from that of NPKM ($P > 0.05$). A significant difference ($P < 0.05$) in the average biomass yield among NPKM, 1.5NPKM, and M implies that 12 t/ha/year is the proper amount of manure for the combination with inorganic fertilisers to harvest higher yield was reported by Zaituniguli *et al.* (2021).

Bhattacharyya *et al*. (2012) found that plots under zero tillage (ZT) had similar mean total aboveground biomass yields (grain + straw) of rice, wheat, and rice + wheat compared to conventional tillage (CT) plots over four years. However, fertilization had a significant impact on the aboveground biomass yields of both crops. Biomass yields exhibited varied trends in response to different fertilization treatments. The biomass of the control (CK) significantly decreased over the years, while biomass in other treatments fluctuated without a clear upward trend.

Table 1 : Effect of long-term manuring and fertilization on biomass of wheat under sorghum wheat cropping sequence.

Treatments		Above Ground Biomass	Below Ground Biomass	Total Biomass
		(Mg ha^{-1})		
T_1	50% NPK	0.51	0.31	0.82
T_2	100% NPK	0.6	0.38	0.98
T_3	150% NPK	0.65	0.43	1.08
T_4	100 %NPK (-S)	0.54	0.37	0.91
T_5	100 % NPK + Zn@ 2.5 kg ha^{-1}	0.6	0.39	0.99
T_6	100 % NP	0.52	0.33	0.85
T_7	100 % N	0.43	0.23	0.66
T_8	100 % NPK+ FYM @ 5 t ha^{-1}	0.71	0.49	1.2
T_9	100 % NPK + S @ 37.5 kg ha^{-1}	0.61	0.4	1.01
T_{10}	FYM @ 10 t ha^{-1}	0.49	0.3	0.79
T_{11}	75% NPK + 25 % N through FYM	0.68	0.47	1.15
T_{12}	Control	0.44	0.21	0.65
SE (m) ±		0.0084	0.0079	0.0082
CD @ 5%		0.026	0.026	0.026

Correlation among yield of wheat and biomass

The correlation between wheat grain production and several biomass components above-ground biomass (AGB), below-ground biomass (BGB), and total biomass under long-term manuring and fertilization in a sorghum–wheat cropping system are shown collectively in Figure-2 (a, b and c respectively). Improvements in biomass are tightly linked to improvements in grain yield, as seen by the strong positive linear relationship seen in every instance.

The components that have the strongest correlation with yield are BGB (R^2 = 0.9768), total biomass (R^2 = 0.9445), and AGB (R^2 = 0.9281). All of the regressions' high coefficients of determination demonstrate how long-term nutrient management techniques significantly increase biomass output, which in turn has a significant impact on yield performance. These patterns imply that crop productivity can be accurately predicted by both above- and below-ground biomass, which reflects enhanced nutrient uptake, root development, and carbon assimilation under consistent fertilization and manuring.

The similar correlation for durum wheat under Mediterranean conditions in different developmental phases (r = 0.87; 0.78) was reported by Aparicio *et al.,* 2002. Elena Petcu *et al.* (2003) results indicate a close correlation between leaf area index and biomass until anthesis phase and between biomass and the yield of wheat.

The highest in grain yield of wheat with balanced fertilizer application along with FYM or organics was also reported by Singh *et al.* (2012) and Sawarkar *et al.* (2013). Ram *et al.* (2016) stated that, long-term integrated use of inorganic fertilizers and organic manure (FYM) was found superior in comparison with sole application of inorganic fertilizers in sustaining the crop productivity and soil fertility.

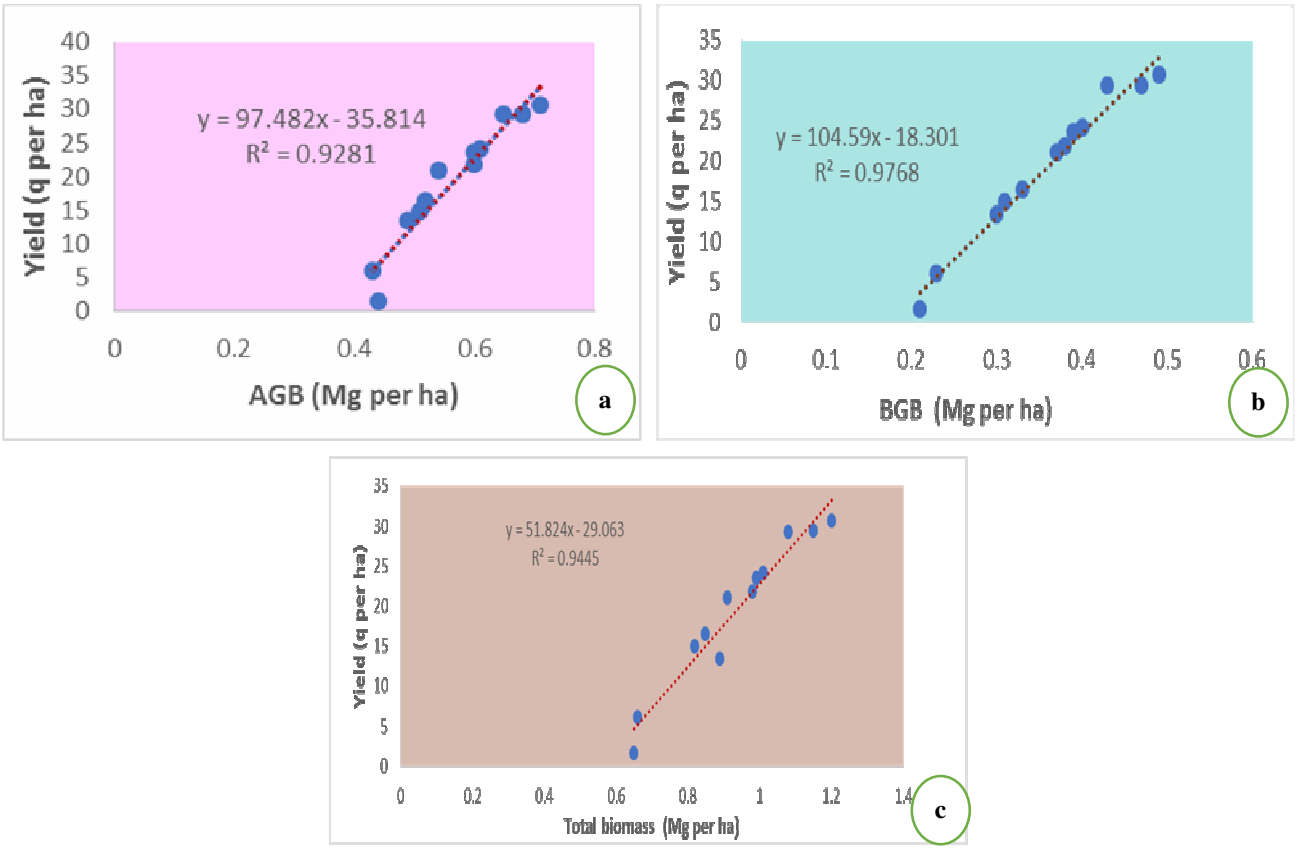

Fig. 2 : Correlation among wheat grain yield and biomass components under long term manuring and fertilization in a sorghum-wheat cropping sequence

(a) relationship between grain yield and above-ground biomass,
(b) relationship between grain yield and below-ground biomass, and
(c) relationship between grain yield and total biomass

Conclusion

The combined application of organic and inorganic fertilizers significantly improved above-ground, below-ground and total biomass, as well as wheat grain yield. Long-term integrated nutrient management proved superior to sole inorganic fertilization, contributing to sustainable wheat production and improved soil fertility in Vertisol.

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