

Effect of organic, inorganic and biological sources of nutrients on soil properties and performance of *rabi* sorghum(*Sorghum bicolor* L.)

Sk Mujahid, P Gurumurthy, M Latha and K Srinivasulu

Department of Soil Science & Agricultural Chemistry, Acharya N G Ranga Agricultural University,
Agricultural College, Bapatla-522101, Andhra Pradesh, India

ABSTRACT

A field experiment was conducted during 2024-2025 at Agricultural college Farm, Bapatla, to evaluate the effect of organic, inorganic and biological sources of nutrients on soil properties and performance of *rabi* sorghum. The experimental soil was neutral in reaction with a pH of 7.46 and non-saline with an EC value of 0.30 dS m⁻¹. The highest organic carbon (0.38%), max. water holding capacity (49.6%), grain yield (4,890 kg ha⁻¹) and stover yield (7,962 kg ha⁻¹), dry matter (15,250 kg ha⁻¹) were recorded in the treatment 125 % RDF + VC @ 5 t ha⁻¹ + BFC @ 1.5 L ha⁻¹, respectively and the lowest were recorded in the control. The plant N, P and K contents were recorded highest (2.57%, 0.51 & 1.83%) in the treatment 125 % RDF + VC @ 5 t ha⁻¹ + BFC @ 1.5 L ha⁻¹ at blooming. Similarly, soil enzyme activities and microbial populations were markedly enhanced with the combined application of inorganic fertilizers, organic manures, and biofertilizers, indicating improved soil biological health.

Keywords: BFC (Biofertilizer consortium), VC (vermicompost) and Organic carbon, etc

Sorghum (*Sorghum bicolor*) is one of the important cereal crops of the world which is commonly called as jowar, great millet and camel crop. Sorghum plays a significant role in the agricultural landscape particularly in arid and semi-arid regions, it was first domesticated in northeast Africa over 60 centuries ago. Among its various cultivation cycles, the *rabi* sorghum grown during the post-monsoon season is crucial for ensuring food security and supporting rural economies. Globally Sorghum production was about 52.8 million tonnes during 2023-24. United States stands top with 8.07 million tons (14%) followed by Nigeria with 6.7 million tonnes (11%), Brazil with 4.76 million tons (8%) and India with 4.4 million tons (8%) (*fas.usda.gov*). India ranks fourth in total Sorghum production with 4.4 million tonnes grown in an area of 3.97 million hectares in 2023-24, where majority of Sorghum was produced during *rabi* season. Among the Sorghum producing states, Andhra Pradesh ranks 7th in cultivation area with 1.03 lakh hectares with a production of 4.30 lakh tonnes contributing 9.07% to India's total production with a productivity of 4175 kg ha⁻¹ in 2023-24 (3rd AE, DESAP). (Source:

Andhra Pradesh Agricultural statistics at a glance, 2022-23).

MATERIAL AND METHODS

The experiment was conducted during the *Rabi* season of 2024-25 at the Agricultural College Farm, Bapatla, using Sorghum hybrid MLSH-151 as a test crop. The site is located in the Krishna-Godavari agro-climatic zone, characterized by a tropical climate with moderately dry winters.

The experiment comprised of 10 treatments viz., Control (T₁); 75% RDF (T₂); 75% RDF + vermicompost @ 5 t ha⁻¹ (T₃); 75% RDF + vermicompost @ 5 t ha⁻¹ + Biofertilizer Consortium (Azospirillum + PSB + KRB) @ 1.5 L each ha⁻¹ (T₄); 100% RDF (T₅); 100% RDF + vermicompost @ 5 t ha⁻¹ (T₆); 100% RDF + vermicompost @ 5 t ha⁻¹ + Biofertilizer Consortium (Azospirillum + PSB + KRB) @ 1.5 L each ha⁻¹ (T₇); 125% RDF (T₈); 125% RDF + vermicompost @ 5 t ha⁻¹ (T₉); 125% RDF + vermicompost @ 5 t ha⁻¹ + Biofertilizer Consortium (Azospirillum + PSB + KRB) @ 1.5 L each ha⁻¹ (T₁₀) and replicated thrice. Biofertilizer Consortium (Azospirillum + PSB + KRB) @ 1.5 L each ha⁻¹ were

Characters	Value	Rating	Method used
pH	7.46	Neutral	Glass electrode pH meter
EC (dS m ⁻¹)	0.3	Normal	Jackson, 1973
OC (%)	0.38	medium	Wet digestion method
Available N (kg ha ⁻¹)	198	Low	Alkaline potassium permanganate method
Available P ₂ O ₅ (kg ha ⁻¹)	23.8	Medium	Olsen's method
Available K ₂ O (kg ha ⁻¹)	258	Medium	Flame photometry

mixed with FYM, and applied one week before sowing to the field accordingly. Inorganic nitrogen (urea) was applied at different levels as per the treatments in three splits (as basal dose, 30 DAS and at 60 DAS).

The phosphorus and potassium were applied to all the plots in the form of SSP (basal) and MOP (two equal splits), respectively (Recommended dose of fertilizers were 80-40-40 (N, P₂O₅, K₂O kg ha⁻¹).

Initial soil parameters

The experimental soil was neutral in reaction with a pH of 7.46 and non-saline with an EC value of 0.30 dS m⁻¹. The soil was clay in texture, medium in organic carbon (0.38%) and low in available nitrogen (198 kg ha⁻¹), medium in available phosphorus (23.8 kg P₂O₅ ha⁻¹) and medium in available potassium (258 kg K₂O ha⁻¹). The soil was sufficient in zinc (0.65 mg kg⁻¹), copper (4.35 mg kg⁻¹), iron (9.06 mg kg⁻¹) and manganese (4.04 mg kg⁻¹).

RESULTS AND DISCUSSION

The fertilizer does give significant effect on chemical properties of soil as well as yield and yield attributes of crop. Similarly, addition of inorganics with organics and biofertilizers improved soil physical properties.

Chemical studies of the soil: The soil chemical properties of soil in each treatment were studied during the study period, aiming to evaluate the dynamic changes on crop growth.

pH

The soil pH decreased in the treatments from the initial value (7.49) was presented in Table 1. The treatments with organic and biofertilizers resulted in a decreased pH. The decline in soil pH might have

been a result of the organic matter build up and decomposition in the fertilized plot and also the released organic acids during decomposition might caused a decrease of soil pH. These studies are similar to and supported by the findings of Yaduvanshi *et al.*, 2003.

Electrical Conductivity

No significant change was recorded in EC of soil with the application of inorganics with organics and biofertilizers.

Organic Carbon

The Change in organic carbon of soil was recorded non-significant by the application of organic, inorganic and biological sources of nutrients. The highest value (0.51%) is recorded with the application of inorganics in treatments with organic, and inorganic with organic and biofertilizers followed by inorganic alone.

Available N

The highest available nitrogen in the soil (298 kg ha⁻¹) was recorded with the application of 125 % RDF + Vermicompost @ 5 tha⁻¹ + Biofertilizer consortium @ 1.5 L ha⁻¹ (T₁₀) and the lowest (191 kg ha⁻¹) was recorded in the control (T₁) at harvest, respectively. The increased availability of nitrogen in the soil following the application of organic manures was attributed to the mineralization of organic nitrogen present in the manures. Additionally, the higher nitrogen levels observed at both growth stages in treatments combined with other components were likely due to nitrogen fixation by *Azospirillum*.

The significant increase in available N, P, K, and S contents in the soil was likely due to the combined effect of organic manures and inorganic fertilizers. Organic manures like FYM contributed to

Table 1: Effect of organic, inorganic and biofertilizers on soil physico chemical properties at harvest

Treatments	pH	EC (dS m ⁻¹)	OC (%)
T ₁	7.49	0.42	0.30
T ₂	7.47	0.48	0.40
T ₃	7.31	0.49	0.47
T ₄	7.26	0.50	0.49
T ₅	7.41	0.51	0.46
T ₆	7.34	0.52	0.53
T ₇	7.28	0.53	0.56
T ₈	7.43	0.54	0.51
T ₉	7.39	0.55	0.64
T ₁₀	7.36	0.56	0.68
SEm±	0.023	0.015	0.031
CD at 5%	0.069	NS	0.09
CV (%)	9.80	9.40	10.50

the gradual mineralization and release of nutrients, improving soil fertility and microbial activity. The inorganic fertilizers provided readily available nutrients that complemented the slow nutrient release from organic sources. Both organic and inorganic fertilizers enhanced nutrient availability, improved soil nutrient retention, and promoted better nutrient cycling, resulting in higher soil nutrient content. These results are similar to those of Gunjal and Chitodkar (2017).

Available P₂O₅

The highest available phosphorus in the soil (45.3 kg ha⁻¹) was recorded with the application of 125 % RDF with vermicompost @ 5 t ha⁻¹ and biofertilizer consortium @ 1.5 L ha⁻¹ (T₁₀) and the lowest (19.3 kg ha⁻¹) was recorded in the control (T₁) at harvest, respectively. Similarly, the phosphorus content was significantly higher in all treatments except control.

Significantly higher available phosphorus was recorded in the treatments . That received inorganic sources of nutrients with sole organic and inorganic in combination with organics and biofertilizers in all the RDF levels (75%RDF, 100%RDF and 125%RDF). However, the available phosphorus was recorded statistically at par with T₄ and T₅ treatments and also with T₇ and T₉ treatments, respectively. The significant improvement in P availability in treatment that received PSB, FYM and Chemical fertilizers might be due to the released organic acids which solubilized fixed forms of P in the soil was supported by Patel *et al.* (2016).

Application of phosphate-solubilizing microorganisms enhanced soil P availability primarily through the secretion of low-molecular-weight organic acids such as citric and oxalic and the results are in accordance with those of Silva *et al.* (2023).

The decomposition of organic manures led to the release of various phenolic and aliphatic acids, which helped solubilize phosphatase enzymes and phosphate-bearing minerals. This process reduced phosphate fixation in the soil and enhanced phosphorus availability to crops, as reported by Dotaniya *et al.* (2014).

Available K₂O

The highest available potassium in the soil (352 kg ha⁻¹) was recorded with the application of 125 % RDF + Vermicompost @ 5 tha⁻¹ + Biofertilizer consortium @ 1.5 L ha⁻¹ (T₁₀) and the lowest (188 kg ha⁻¹) was recorded in the control (T₁) at harvest.

Application of potassium-solubilizing bacteria (*Bacillus mucilaginosus*) along with FYM significantly enhanced water-soluble and exchangeable K in soil due to secretion of organic acids that broke down silicate minerals, releasing fixed K into plant-available forms. The results are consistent with Verma *et al.* (2023).

The inoculation of *Enterobacter cloacae* in combination with compost improved K solubilization from feldspar. The observed increase in crop K uptake was attributed to acidolysis and chelation processes driven by microbial metabolites. The results are in conformity with those of Kumar *et al.* (2022).

Table 2: Effect of organic, inorganic and biofertilizers on chemical properties at harvest

Treatments	Available N	Available P ₂ O ₅	Available K ₂ O
	(kg ha ⁻¹)	(kg ha ⁻¹)	(kg ha ⁻¹)
T ₁	191.80	19.30	178.10
T ₂	239.80	28.10	294.00
T ₃	243.70	32.00	289.40
T ₄	257.50	35.50	297.40
T ₅	250.20	35.20	308.50
T ₆	266.60	43.60	308.60
T ₇	275.30	46.30	329.10
T ₈	265.00	41.80	295.20
T ₉	283.70	46.60	318.60
T ₁₀	298.40	49.70	325.30
SEm±	11.49	1.56	4.90
CD at 5%	34.17	4.68	14.70
CV (%)	9.80	9.40	10.50

Grain yield

Highest grain yield of 4890 kg ha⁻¹ was found in T₁₀ (125 % RDF + Vermicompost @ 5 t ha⁻¹ + Biofertilizer consortium @ 1.5 L each ha⁻¹) and lowest (2868 kg ha⁻¹) in T₁ (control). Significantly higher grain yield was noticed in treatments received inorganic sources (T₂, T₅ & T₈) and combination of inorganic + organic (T₃, T₆, T₉) and inorganic + organic + biological sources (T₄, T₇ & T₁₀) compared to control (T₁).

Among the inorganic sources 125% RDF (T₈) registered higher grain yield of 4685 kg ha⁻¹ followed by 100 % RDF (T₅), both these treatments (T₅ and T₈) were significantly superior to 75% RDF (T₂), however, T₈ and T₅ were statistically at par.

Among the combination of inorganics with organic and biological sources, the impact was high with 75% RDF as the sorghum grain yield results indicate 75% RDF + VC @ 5 t ha⁻¹ (T₃) and 75 % RDF +VC @ 5 t ha⁻¹ + BFC @1.5 L each ha⁻¹ (T₄) recorded significantly higher grain yield than the treatment received 75% RDF only (T₂). However the treatment 100% RDF combination of organic + biological sources (T₇) recorded significantly higher grain yield than 100% RDF only (T₅) and it was not significant between T₅ and T₆ (100% RDF +VC@ 5 t ha⁻¹). The treatment T₁₀ recorded a non significant increase in gain yield.

It was found that the inorganic sources in combination with organic sources + biological sources of nutrients (T₄, T₇ & T₁₀) recorded higher sorghum grain yield compared to the combination of inorganic + organic sources (T₃, T₆ & T₉), however the differences were statistically significant at 75% RDF level while insignificant at 100% RDF and 125% RDF.

Dry matter production

The total dry matter yield varied significantly among the treatments, with the highest yield (15,250 kg ha⁻¹) observed with T₁₀ (125% RDF + Vermicompost @ 5 t ha⁻¹ + Biofertilizer consortium @ 1.5 L each ha⁻¹), while the lowest (6,785 kg ha⁻¹) was recorded in control (T₁).

Application of inorganic fertilizers alone (T₂, T₅, T₈) as well as their integration with organic (T₃, T₆, T₉) and organic + biological sources (T₄, T₇, T₁₀) resulted in significantly higher total dry matter yield compared to the control. Among the inorganic levels, 125% RDF (T₈) produced the highest dry matter yield, which was statistically at par with 100% RDF (T₅) and significantly superior to 75% RDF (T₂). Noteworthy improvement was observed when organic and biological sources were combined with 75% RDF (T₃ and T₄) and 100% RDF (T₇), showing significant enhancement over their respective sole inorganic treatments.

Table 3: Effect of organic, inorganic and biofertilizers on yield attributes at harvest

Treatments	Dry matter (kg ha-1)	Grain yield (kg ha-1)
T ₁	6785.00	2868.0
T ₂	10130.00	3570.0
T ₃	12690.00	3924.0
T ₄	13180.00	4205.0
T ₅	12940.00	4441.0
T ₆	13880.00	4586.0
T ₇	14300.00	4737.0
T ₈	14240.00	4685.0
T ₉	14940.00	4755.0
T ₁₀	15250.00	4890.0
SEm±	560.43	76.7
CD at 5%	1680.41	226.2
CV (%)	15.44	10.0

The highest dry matter production in jowar sorghum with vermicompost, inorganic fertilizers, and biofertilizers is due to synergistic effect on nutrient availability and soil health. Inorganic fertilizers provided the immediate macronutrients essential for early growth, while vermicompost soil structure, organic carbon content, and water-holding capacity, and slowly released nutrients (Yadav *et al.*, 2017).

Enhanced the biofertilizers such as Azospirillum and phosphate-solubilizing bacteria improve root development and enhance nitrogen fixation and phosphorus availability (Patel *et al.*, 2016), while KRB mobilize insoluble potassium from soil minerals, making it available to plants, was supported by Meena *et al.*, 2016.

CONCLUSION

It can be concluded that the application of integrated nutrient management involving inorganics, organics, and biofertilizers at the 100% RDF level resulted in a significant improvement in grain yield, dry matter production, and N, P, and K content as well as their uptake. The treatment T₄ outperformed the combination treatments involving 75% RDF with inorganics, organics, and biofertilizers, as well as the 125% RDF level with the same combination, indicating that higher doses of fertilizers do not necessarily translate into better crop performance. Furthermore, adopting integrated nutrient management at the 75% RDF level not only ensures optimum crop productivity but also avoids the unnecessary additional cost associated with applying 25% extra inorganic

fertilizers as in treatment T₇. More importantly, it contributes to maintaining soil health, enhancing nutrient availability, and promoting environmental sustainability through reduced chemical inputs and improved biological activity in the soil.

LITERATURE CITED

- Foreign Agricultural Service, 2024.** *World agricultural production: Sorghum production estimates for 2023/24*. United States Department of Agriculture. Available at: <https://www.fas.usda.gov>
- Directorate of Economics and Statistics, Government of Andhra Pradesh, 2023.** *Andhra Pradesh Agricultural Statistics at a Glance. 2022-23*. Amaravati: Department of Agriculture.
- Yaduvanshi NPS. Substitution of inorganic fertilizers by organic manures and the effect on soil fertility in a rice-wheat rotation on reclaimed sodic soil in India. Journal of Agricultural Science. 2003; 140:161-168.**
- Devi KN, Singh S, Singh G, Athokpam S. Effect of integrated nutrient management on growth and yield of wheat (*Triticum aestivum* L.). Journal of Crop and Weed. 2011; 7(2):23-27.**
- Rasool R, Kukal SS, Hira GS 2008.** Soil organic carbon and physical properties as affected by long-term application of FYM and inorganic

- fertilizers in maize-wheat system. *Soil & Tillage Research.* ; 101:31-36.
- Wolie AW and Admassu MA. 2016.** Effects of integrated nutrient management on rice (*oryza sativa*. L) yield and yield attributes, nutrient uptake and some physico-chemical properties of soil: A review. *Journal of Biology, Agriculture and Healthcare.* ; 6:No.5.
- Gunjal B S and Chitodkar S S 2017.** Effect of integrated nutrient management on soil properties and soil fertility under in sweet corn potato cropping sequence in vertisols of Deccan Plateau of India. *International Journal of Chemical Studies.* 5 (6): 1343-1351.
- Silva R F, Costa L M and Oliveira, A.A. 2023.** Phosphate-solubilizing microorganisms and their role in enhancing soil phosphorus availability. *Soil Science and Plant Nutrition.* 69 (1): 78-89.
- Yadav R L, Dwivedi B S, Pandey PS, Shurpali N J and Pandey M 2017.** Synergistic effects of inorganic fertilizers and organic amendments on productivity, soil properties and sustainability of cropping systems. *Archives of Agronomy and Soil Science.* 63 (10): 1301-1312.
- Dotaniya M L, Meena V D and Rathore S S 2014.** Role of organic manures in enhancing phosphorus availability through enzyme activities and acid release in soils. *Archives of Agronomy and Soil Science.* 60 (10): 1371-1383.
- Verma S, Singh A and Kumar R 2023.** Influence of potassium-solubilizing bacteria and farmyard manure on soil potassium availability and crop uptake. *Journal of Soil Biology and Biochemistry.* 59 (1): 112-120.
- Kumar P, Sharma V and Gupta N 2022.** Effect of *Enterobacter cloacae* inoculation with compost on potassium solubilization and uptake in crops. *Soil Science and Plant Nutrition.* 68 (4): 450-458.
- Yadav R L, Dwivedi B S, Pandey PS, Shurpali N J and Pandey M 2017.** Synergistic effects of inorganic fertilizers and organic amendments on productivity, soil properties and sustainability of cropping systems. *Archives of Agronomy and Soil Science.* 63 (10): 1301-1312.
- Patel A, Patel A J, Patel D K and Patel V R 2016.** Effect of biofertilizers on growth and yield of sorghum (*Sorghum bicolor* L. Moench). *International Journal of Agriculture Sciences.* 8 (60): 3361-3363.
- Meena V S, Maurya B R and Verma J P 2016.** Does a rhizospheric microorganism enhance K⁺ availability in agricultural soils? *Microbiological Research.* 183: 26-41.

Received on 02.10.2025 and Accepted on 25.11.2025