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Effect of integrated nutrient management on growth dynamics of sorghum (*Sorghum bicolor* L.) under Southern Rajasthan

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Abstract

A field experiment was conducted during *kharif*, 2025 at the Instructional Farm, Department of Agronomy, Rajasthan College of Agriculture, MPUAT, Udaipur, to study the effect of integrated nutrient management on growth dynamics of sorghum (*Sorghum bicolor* L.) under Southern Rajasthan. The experiment was laid out in a split-plot design with four fertility levels, namely control, 50% RDF, 75% RDF and 100% RDF and four organic sources, namely control, FYM @ 10 t ha⁻¹, vermicompost @ 3 t ha⁻¹ and NPK consortia @ 5 l ha⁻¹, replicated three times. The recommended dose of fertilizer was 80:40:40 kg N: P₂O₅:K₂O ha⁻¹ and half nitrogen with full phosphorus and potassium were applied at sowing while the remaining nitrogen was top-dressed in splits. The experimental results showed that application of 100% RDF recorded significantly higher values of growth parameters viz., plant height (204.91 cm) and dry matter accumulation (123.91 g plant⁻¹) at harvest in sorghum which was superior to lower fertility levels and was at par with 75% RDF. Among the organic sources, application of vermicompost @ 3 t ha⁻¹ recorded significantly higher values of plant height (200.83 cm) and dry matter accumulation (122.47 g plant⁻¹) at harvest which was found superior over control and FYM but statistically at par with NPK consortia. The results indicated that application of 100% RDF in combination with vermicompost @ 3 t ha⁻¹ had a positive effect on the growth of sorghum.

Keywords: Sorghum, fertility levels, organic sources, growth parameters, integrated nutrient management

Introduction

Sorghum (*Sorghum bicolor* L.) is an important cereal crop of the family Poaceae and sub-family Panicoideae. Owing to its remarkable adaptability to diverse environmental conditions, it is extensively cultivated throughout the world during both *kharif* and *rabi* seasons. It was originated from Africa, where it was domesticated over 5,000 years ago and has spread throughout the globe. This crop is under the category of hardy nature (prone to drought condition) and cultivated for various purposes like grains, animal feeds, fodder and industrial uses. Sorghum grains contain about 70 per cent carbohydrate, 10-12 per cent protein and 3 per cent fat. It is an excellent source of dietary fiber, iron, phosphorus, B-complex vitamins and is naturally gluten-free. Amongst cereals, sorghum is the 4th most important crop after rice, wheat and maize. During 2024-25, global area, production and productivity of sorghum were 41.47 million hectares, 63.42 million tonnes and 1530 kg ha⁻¹, respectively, whereas in India, these were 4.80 million hectares, 6.00 million tonnes and 1250 kg ha⁻¹, respectively (USDA, 2025)^[18]. In the state of Rajasthan during 2024-25, sorghum occupies an area of about 0.64 million hectares with an annual production of 0.54 million tonnes and productivity of 846 kg ha⁻¹ (DA & FW, 2025)^[4].

Integrated Nutrient Management (INM), which combines organic manures (like FYM and vermicompost), liquid bio-consortia (such as *Azospirillum* and PSB) and chemical fertilizers, plays a vital role in improving yield, nutrient uptake and soil health. Sawargaonkar and Wani (2016)^[15] found phosphorus combined with N increased sugar and ethanol yield in sweet sorghum at ICRISAT. Mali *et al.* (2011)^[10] observed that K fertilization improved soil fertility

and nutrient uptake in long-term trials. FYM is a term used to describe the degraded mixture of farm animal faeces, urine, litter and leftovers from roughages or cow feed. There are 0.5 per cent nitrogen, 0.2 per cent phosphorus and 0.5 per cent potassium in a well-decomposed FYM. Farmyard manure provides many benefits, including enhancing the soil with humus and slowly-releasing nutrients that aid in retaining water and nutrients while also promoting soil microbial activity. Comparing the organic lettuce production method to the conventional one, a high yield is observed when green manure and FYM are used together (Caliskan *et al.*, 2014) ^[3].

Vermicompost is one of the most important organic manures used in sustainable agriculture due to its rich nutrient composition, beneficial microbial population and positive effects on soil health. It improves soil physical, chemical and biological properties, enhances nutrient availability and promotes better crop growth and productivity. NPK (nitrogen 1.3-1.7%, phosphorus 0.91-1.12% and potassium 0.85-1.32%) is abundant in vermicompost. Vermicompost is now become very popular and the use of vermicompost has an important input in the integrated plant nutrient management (Singh and Ganguly, 2005) ^[16].

Bio-fertilizer is generally defined as a material which contains living micro-organism. It is the preparations containing proficient strains of nitrogen fixing, phosphorus solubilizing phototrophic or cellulolytic micro-organism. With several benefits over agrochemicals, liquid biofertilizer formulation is a promising and modernized version of the traditional carrier-based production process. A study found that liquid biofertilizer consortia (*Azospirillum* + PSB) at 4 ml kg⁻¹ increased biomass and grain yield significantly (Rani *et al.*, 2019) ^[14].

Material and methods

A field experiment was conducted at block E₁, Instructional Farm, Department of Agronomy, Rajasthan College of Agriculture, MPUAT, Udaipur during *kharif*, 2025. The experimental soil was clay-loam in texture, slightly alkaline in reaction (pH 7.6), low in organic carbon and available nitrogen, medium in available phosphorus and high in available potassium. The experiment was laid out in a split-plot design with three replications, comprising four fertility levels in the main plot, viz. control, 50% RDF, 75% RDF and 100% RDF and four organic sources in the subplots, viz. control, FYM @ 10 t ha⁻¹, vermicompost @ 3 t ha⁻¹ and NPK consortia @ 5 l ha⁻¹. The test crop was sorghum variety CSV 23, sown at a spacing of 45 cm × 15 cm with a seed rate of 10 kg ha⁻¹. The recommended dose of fertilizer was 80:40:40 kg N:P₂O₅:K₂O ha⁻¹ and half nitrogen with full phosphorus and potassium were applied at sowing through urea, DAP and MOP, while the remaining nitrogen was applied in two equal splits at 30 and 45 DAS. Farmyard manure @ 10 t ha⁻¹ and vermicompost @ 3 t ha⁻¹ were applied 15 days before sowing and incorporated into the soil whereas NPK consortia was applied as seed treatment. The crop was managed through thinning, pre-emergence atrazine, post-emergence metsulfuron-methyl and hand weeding at critical stages. Observations were recorded on plant height and dry matter accumulation using standard procedures and the data were analyzed by ANOVA as per split-plot design (Panse and Sukhantme, 1985) ^[12].

Results and discussion

Fertility levels: During *kharif* 2025, fertility levels had a significant effect on all growth parameters of sorghum. The results demonstrated that application of 100% RDF recorded the

highest values of important growth parameters such as plant height (204.91 cm) and dry matter accumulation plant⁻¹ (123.91 g plant⁻¹) at harvest, crop growth rate (CGR), relative growth rate (RGR), leaf area index at 60 DAS (2.34).

Plant height remained non-significant at 25 DAS, possibly because seedlings mainly depend upon seed reserves during the early growth stages. However, significant improvement at later stages might be due to improved nutritional status of the plant, which enhanced the synthesis of amino acids, proteins and growth-promoting substances, thereby stimulating meristematic activity, cell division and cell elongation. Similar findings were reported by Sawargaonkar and Wani (2016) ^[15] and Kubsad (2018) ^[9]. Dry matter accumulation plant⁻¹ was maximum with the application of 100% RDF. This enhancement might be attributed to improved morphological growth of plants, which facilitated greater interception and efficient utilization of solar radiation, thereby promoting higher photosynthetic activity. Afzal *et al.* (2012) ^[11] also reported that higher fertility levels significantly increased plant height and biomass production due to improved nutrient availability and photosynthetic efficiency. Crop growth rate (CGR) and relative growth rate (RGR) also increased significantly with increasing fertility levels due to rapid biomass accumulation and efficient utilization of nutrients. Leaf area index (LAI) was also higher under 100% RDF at different growth stages, possibly due to enhanced nitrogen and potassium availability, which promoted leaf number, leaf growth and leaf surface area. Similar results were reported by Muchow and Carberry (1988) ^[11].

Organic sources

Among the organic sources, vermicompost @ 3 t ha⁻¹ recorded significantly higher plant height (200.83 cm), dry matter accumulation (122.47 g plant⁻¹), leaf area index (2.32), crop growth rate (CGR) and relative growth rate (RGR), remained statistically at par with NPK consortia for most of the parameters. Correlation studies further revealed a significant and positive relationship between dry matter accumulation at harvest and plant height at harvest ($r = 0.812$) as well as LAI at 60 DAS ($r = 0.856$), indicating that improved plant growth and canopy development contributed substantially towards biomass accumulation.

The superior growth performance under vermicompost might be attributed to its rich nutrient composition, narrow C-N ratio and faster mineralization, which ensured continuous and balanced nutrient availability throughout the crop growth period. Vermicompost also improved soil structure, aeration, water holding capacity and microbial activity, thereby enhancing nutrient uptake, photosynthetic efficiency and biomass accumulation. Similar findings were reported by Patil *et al.* (2018) ^[13], Tudu *et al.* (2023) ^[17] and Balai *et al.* (2024) ^[2]. NPK consortia remained statistically at par with vermicompost for most growth parameters, which might be due to the presence of beneficial micro-organisms capable of nitrogen fixation, phosphorus solubilization and potassium mobilization, thereby improving nutrient availability and uptake. Enhanced microbial activity under NPK consortia possibly improved rhizospheric conditions and nutrient use efficiency, resulting in growth performance comparable to vermicompost. Similar observations were reported by Jat *et al.* (2013) ^[7] and Deshmukh *et al.* (2013) ^[5]. In contrast, FYM recorded comparatively lower growth parameters, which may be attributed to its lower nutrient concentration, wider C-N ratio, slower decomposition and mineralization rate. The nutrients from FYM are released gradually and may not synchronize effectively with crop

demand during critical growth stages, resulting in comparatively lower nutrient availability and biomass production. Similar

findings were also reported by Krishnaprabu (2014) ^[8] and Gaikwad *et al.* (2018) ^[6].

Table 1: Effect of integrated nutrient management on plant height of sorghum

Treatments	Plant height (cm)			
	25 DAS	50 DAS	75 DAS	At harvest
Fertility levels				
F ₀ : Control	35.70	116.45	137.64	179.80
F ₁ : 50% RDF	36.01	124.92	153.12	197.71
F ₂ : 75% RDF	37.74	133.31	167.22	204.67
F ₃ : 100% RDF	38.93	136.35	171.73	204.91
S.E.m.±	1.00	2.11	2.49	3.15
C.D. (P= 0.05)	NS	7.31	8.62	10.91
Organic sources				
O ₀ : Control	36.07	121.30	152.48	191.80
O ₁ : FYM (10.0 t ha ⁻¹)	36.98	126.19	155.80	194.99
O ₂ : Vermicompost (3.0 t ha ⁻¹)	37.46	132.14	160.78	200.83
O ₃ : NPK consortia (5.0 l ha ⁻¹)	37.88	131.41	160.65	199.48
S.E.m.±	0.63	1.86	2.04	1.89
C.D. (P= 0.05)	NS	5.42	5.96	5.52

Table 2: Effect of integrated nutrient management on dry matter accumulation and leaf area index of sorghum

Treatments	Dry matter accumulation (g plant ⁻¹)				Leaf area index
	25 DAS	50 DAS	75 DAS	At harvest	60 DAS
Fertility levels					
F ₀ : Control	10.03	45.11	89.94	115.73	1.99
F ₁ : 50% RDF	11.51	48.75	92.96	118.90	2.16
F ₂ : 75% RDF	11.82	49.42	94.12	123.08	2.24
F ₃ : 100% RDF	12.12	50.82	94.88	123.91	2.34
S.E.m.±	0.71	0.42	0.26	0.59	0.07
C.D. (P= 0.05)	NS	1.47	0.90	2.03	0.16
Organic sources					
O ₀ : Control	10.61	46.53	90.96	116.78	2.03
O ₁ : FYM (10.0 t ha ⁻¹)	10.88	48.21	92.81	120.68	2.10
O ₂ : Vermicompost (3.0 t ha ⁻¹)	11.90	49.90	94.17	122.47	2.32
O ₃ : NPK consortia (5.0 l ha ⁻¹)	12.09	49.46	93.97	121.68	2.28
S.E.m.±	0.61	0.42	0.30	0.60	0.06
C.D. (P= 0.05)	NS	1.23	0.87	1.76	0.17

Table 3: Effect of integrated nutrient management on growth indices of sorghum

Treatments	CGR (g m ⁻² day ⁻¹)			RGR (g g ⁻¹ day ⁻¹)		
	25 - 50 DAS	50-75 DAS	75 DAS - At harvest	25 - 50 DAS	50-75 DAS	75 DAS - At harvest
Fertility levels						
F ₀ : Control	19.54	28.48	8.20	0.137	0.152	0.081
F ₁ : 50% RDF	22.22	28.57	8.45	0.141	0.152	0.081
F ₂ : 75% RDF	22.61	28.84	9.64	0.142	0.152	0.084
F ₃ : 100% RDF	24.02	29.08	9.93	0.144	0.151	0.084
S.E.m.±	0.44	0.31	0.33	0.001	0.001	0.001
C.D. (P= 0.05)	1.52	NS	1.13	0.002	NS	NS
Organic sources						
O ₀ : Control	20.86	28.74	8.41	0.139	0.152	0.081
O ₁ : FYM (10.0 t ha ⁻¹)	21.68	28.56	9.02	0.141	0.152	0.083
O ₂ : Vermicompost (3.0 t ha ⁻¹)	22.98	28.61	9.45	0.143	0.152	0.084
O ₃ : NPK consortia (5.0 l ha ⁻¹)	22.87	29.06	9.34	0.142	0.152	0.083
S.E.m.±	0.26	0.35	0.24	0.001	0.000	0.001
C.D. (P= 0.05)	0.76	NS	0.70	0.001	NS	0.002

Conclusion: Based on findings, it is proposed that application of 100% RDF recorded the best growth performance in sorghum, with the highest plant height and dry matter accumulation. Among the organic sources, vermicompost @ 3 t ha⁻¹ performed best and was better than NPK consortia, FYM and control. Overall, the combined use of 100% RDF and vermicompost @ 3 t ha⁻¹ was most effective for improving growth of sorghum under Southern Rajasthan conditions.

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