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Effect of varieties and integrated nutrient management on productivity and profitability of sorghum (*Sorghum bicolor*)

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ABSTRACT

To study the effect of varieties and integrated nutrient management on yield attributes, yield and economics of sorghum (*Sorghum bicolor*) under sub-tropical condition of Madhya Pradesh an field experiment was conducted at the Crop Research Centre of School of Agriculture, ITM University, Gwalior, (M.P.) during the *kharif* season of 2022 .The experiment was conducted by taking four levels of fertilizers*viz*. T_1-Control, T_2 - 100% RDF, T_3-75% RDF + 25% Vermicompost, T_3 - 50% RDF + 50% Vermicompost and three varieties (V_1 =Mahalakshmi-296, V_2 =Amarnath-2000 V_3= Western jowar in factorial randomized block design which were replicated thrice. The fertilizers were applied as per the requirement of the treatments. The experimental study revealed that among the phosphorus levels, the application of 75% RDF + 25% Vermicompost recorded significantly highest yield attributes and seed yield. However, among the varieties, application of Mahalakshmi-296 resulted in highest yield attributes and yield of Sorghum. Among the economic analysis, application of 75% RDF + 25% Vermicompost and combined treatment of Mahalakshmi-296 incurred the highest cost of cultivation, highest gross return, net return and Benefit cost ratio. Therefore, for Sorghum cultivation, 75% RDF + 25% Vermicompost and combine treatment of Mahalakshmi-296 was proved to be profitable.

Key words: *Vermicompost, Sorghum, Varieties, Yield and Economics.*

Introduction

Sorghum (*Sorghum bicolor* (L.)) holds a significant position as both a grain and pasture crop, playing a crucial role in global agriculture due to its diverse applications. Some varieties are cultivated primarily for their grain, while others serve as fodder crops, and certain types are employed for dual purposes (Harada *et al.,* 2000). Characterized by its tall, erect growth habit and utilization of the C4 photosynthetic pathway, the sorghum plant exhibits remarkable adaptability to varying climatic conditions and soil types. With adventitious roots extending to a depth twice that of the plant's height, sorghum efficiently extracts nutrients from the top 90 cm of soil and beyond. The plant's robust culms, ranging from 0.6 to 5 m in height and 5 to 30 mm in diameter, provide structural support for its substantial leaves. These leaves, resembling those of maize but shorter and wider, contribute to its overall photosynthetic efficiency. Inflorescences, described as panicles up to 60 cm long with thousands of spikelets, mark the transition from vegetative to reproductive growth (Balole *et al.,* 2006).

Sorghum bicolor boasts a wide range of colors and stem characteristics across its genotypes, reflecting its extensive genetic diversity. This diversity underpins its versatility as a food source, livestock fodder, feed ingredient, and biofuel feedstock. With over 24 distinct species within the Sorghum genus, cultivars have emerged from the wild progenitor Sorghum bicolor subsp. varicelliform, a species widely distributed across Africa.

Sorghum's resilience as a C4 cereal fodder crop makes it an invaluable resource for sustainable agriculture. Its drought resistance, tolerance to pH levels ranging from 5.0 to 8.5, and ability to thrive in diverse soil types, except waterlogged and saline conditions, contribute to its popularity across various agroecosystems. In addition to its use in animal feed and fodder, sorghum serves as a feedstock for industrial processes, including biofuel production, sugar refining, and papermaking (Koeppen *et al.,* 2009). This multi-dimensional utility ranks sorghum as the world's fifth most cultivated crop, supporting the production of ethanol, fodder, sugar, grain, and fiber (Yuan *et al.,* 2008).

India's agricultural landscape prominently features sorghum, locally known as "Jawar" or the "Great Millet." It responds positively to effective production management techniques, encompassing strategies such as optimized fertilizer application, irrigation, weed control, and plant protection. Among these factors, fertilization emerges as a critical determinant of sorghum yield. The choice of cultivar and soil moisture availability further influence the demand for fertilizers. However, the varying responses of newly released cultivars to different fertility levels necessitate tailored fertilizer application to ensure optimal productivity (Tandon and Narayan, 1990).

The nutrient requirements of sorghum extend to micronutrients, notably zinc (Zn) and iron (Fe), which play pivotal roles in high-quality fodder production. Efficiently delivering these micronutrients to crops involves soil application of micronutrient fertilizers. India, with its massive livestock population, demands careful nutrient control to ensure sufficient feed and fodder resources. Livestock significantly contribute to India's economy and rural livelihoods, highlighting the critical importance of addressing feed and forage shortages (Jat *et al.,* 2014). However, the current supply falls considerably short of the required green and dry fodder amounts.

Nitrogen (N) is a cornerstone nutrient for Sorghum, influencing leaf and tiller development, photosynthetic efficiency, and overall yield. Its role extends to enzymatic activities, chlorophyll production, and essential vitamins, shaping the quality and quantity of dry matter and protein in crops (Uchida, 2000). Maximizing agricultural productivity often involves the strategic use of fertilizers. Nitrogen, phosphorus, and potassium (NPK) emerge as vital components due to their substantial contribution to plant growth and development. Despite being abundant in soils, phosphorus (P) frequently becomes a limiting factor due to low availability, impacting root development, flowering, and seed formation.

Vermicompost, a product of earthworm-mediated organic decomposition, presents a sustainable option to enhance sorghum productivity. Its gradual nutrient release enables long-term nutrient absorption, promoting vigorous seedling growth, root formation, and biomass production. Moreover, vermicompost's rich microbial diversity supports its role as an effective soil amendment for enhancing crop performance (Arancon *et al.,* 2006; Gashaw *et al.,* 2019).

Materials and Method

The experiment was carried out during *kharif* season of 2022-23 at Crop Research Centre, School of Agriculture, ITM University Gwalior, (M.P.). The experimental site is located situated at 26^0 14´ N latitude and 78^0 14´ E longitude at an elevation of 206 meters above mean sea level.The climate of this place is typically sub-tropical in nature withhigh relative humidity, moderate temperature with medium to high rainfall. The soil of the experimental field wassandy loam in texture, slightly alkaline in reaction (Ph 8.2), low in organic carbon (4.0), available nitrogen (183.50) and potassium (243.0) but medium in available phosphorus (14.4) with electrical conductivity (0.14) in the safer range.

The experiment consists of 12 treatment combination with four fertilizers levels (control, 100% RDF, 75% RDF+ 25% Vermicompost, 50% RDF+ 50% Vermicompost) and varieties (V_1 =Mahalakshmi-296, V_2 =Amarnath-2000 V_3= Western jowar) which was laid out in factorial block design with three replications.

The Sorghum was sown on July, 15^{th} 2022 using seed 10 kg $ha^{-1}$with a spacing of 45 x 15 cm. The crop was harvest on October, 25^{th} 2022. The phosphorus was applied through SSP and potassium. Significant difference of sources of variation was tested at the probability level of 0.05. The standard error of the mean (SEm ±) and the Cd. value was indicated in the tables to compare the difference between the mean values.

Results and Discussion

This research focused on investigating the impact of different fertilizer levels and sorghum varieties on key yield attributes and overall crop productivity. The study demonstrated significant effects of these factors on various aspects of sorghum yield, contributing to a better understanding of agronomic practices for optimizing crop output.

Yield and Yield Attributes Analysis

The study revealed that the number of panicles per plant was notably influenced by both fertilizer levels and sorghum variety. The treatment with 75% RDF + 25% Vermicompost ha^{-1} yielded the highest panicle count, closely followed by 100% RDF ha^{-1}, surpassing the control group. Mahalakshmi-296 emerged as the top-performing sorghum variety in terms of panicle count, corroborating the findings of Kishor *et al.,* 2017. Panicle lengthshowed significant sensitivity to both fertilizer levels and sorghum variety. The treatments involving 75% RDF + 25% Vermicompost ha^{-1} and 100% RDF ha^{-1} produced longer panicles compared to the control, consistent with previous research by Munagilwar *et al.,* 2020. Similarly, Mahalakshmi-296 exhibited the longest panicles, reaffirming the role of genetics in determining this trait. The number of grains per panicle was significantly impacted by both fertilizer levels and sorghum variety. The treatments involving 75% RDF + 25% Vermicompost ha^{-1} and 100% RDF ha^{-1} yielded the highest grain count per panicle, while the control group had the lowest count. Mahalakshmi-296 consistently exhibited the highest grain count per panicle. The application of 75% RDF + 25% Vermicompost ha^{-1} and 100% RDF ha^{-1} led to significantly higher grain yields compared to the control group. Furthermore, specific sorghum varieties, including Mahalakshmi-296, Amarnath-2000, and Western jowar, exhibited the highest grain yields, in line with the findings of Shinde *et al.,* 2017. Stover yield and biological yield, akin to grain yield, were significantly affected by fertilizer levels and sorghum varieties. Treatments involving 75% RDF + 25% Vermicompost ha^{-1} and 100% RDF ha^{-1} resulted

Table 1. Yield attributes, Yield& Economics of sorghum as influenced by different varieties and INM.

Treatment	At harvest										
	No of Panicles	Length of panicle	No of grains $panicle^{-1}$	Test weight	Grain yield (Kg ha^{-1})	Stalk yield (Kg ha^{-1})	Biological yield (Kg ha^{-1})	Harvest index (%)	Gross return	Net return	B : C ratio
Fertilizers (kg ha^{-1})											
Control	9.94	22.71	696.98	27.54	1443.18	6557.26	8000.44	18.16	42997	4958	0.58
100% RDF	14.15	27.03	1096.62	29.82	2872.60	8426.62	11299.22	25.54	85580	7643	2.02
75% RDF+ 25% Vermicompost	16.12	29.29	1187.69	30.28	3634.37	9357.12	12991.48	28.04	108269	9125	2.02
50% RDF+ 50% Vermicompost	12.90	25.65	1036.29	29.13	2853.79	8380.19	11233.98	25.53	85024	11090	0.96
SE(m) ±	0.49	0.74	25.35	0.79	67.47	222.24	236.03	—	2007.12	9323.44	0.05
C.D (P=0.05)	1.45	2.17	74.34	NS	197.88	651.80	692.25	—	5886.67	27344.70	0.16
Varieties											
MahaLakshmi-296	14.40	27.74	1070.42	31.30	2877.07	8656.11	11533.19	24.39	85449	6703	1.55
Amarnath 2000	13.47	26.66	1018.98	29.18	2740.30	8562.98	11303.28	23.71	81386	8276	1.43
Western jowar	11.97	24.11	923.78	27.09	2485.59	7321.79	9807.38	24.85	74567	9633	1.21
SE(m+)	0.43	0.64	21.95	0.69	58.43	192.46	204.41	—	1738.21	8074.33	0.05
C.D (P=0.05)	1.25	1.88	64.38	2.02	171.37	564.48	599.51	—	5098.01	23681.21	0.14

in greater stover and biological yields compared to the control. Mahalakshmi-296 stood out as a top-performing variety for stover and biological yields, echoing the observations of Kishor *et al.,* 2017.

Economics

Among the treatment combinations, the highest cost of cultivation was incurred by the use of 50% recommended dose of fertilizer (RDF) along with 50% vermicompost, combined with the Western jowar variety (V3). In contrast, the lowest cost of cultivation was observed in the control group, which received no additional treatments, and was coupled with the Mahalakshmi-296 variety (V1). This underscores the potential for increased production costs associated with specific treatments like the RDF and vermicompost combination, possibly impacting overall cultivation profitability. These findings are in alignment with prior research conducted by Kishor *et al*. Notably, the treatment blend of 75% RDF and 25% vermicompost, combined with the Mahalakshmi-296 variety (V1), emerged with the highest gross returns. Conversely, the lowest gross return was witnessed in the control group combined with the Western jowar variety (V3). The outcomes demonstrate that the treatment combination of 75% RDF and 25% vermicompost, paired with the Mahalakshmi-296 variety (V1), resulted in the most favourable net returns. Conversely, the control group combined with the Western jowar variety (V3) yielded the lowest net returns. Notably, the treatment combination of 75% RDF and 25% vermicompost, in conjunction with the Mahalakshmi-296 variety (V1), displayed the highest BCR. In contrast, the control group combined with the Western jowar variety (V3) exhibited the lowest BCR. This aligns with the findings articulated by Jat *et al.* (2013).

Conclusion

This study provides valuable insights into the intricate interplay between fertilizer levels and sorghum varieties on yield attributes. The consistency of findings across multiple studies strengthens the credibility of the observed relationships. These results offer practical implications for optimizing agricultural practices and enhancing sorghum productivity, which is vital for sustainable food production and food security. The economic evaluation of different treatment combinations for sorghum cultivation provides valuable insights into the cost-effectiveness of varying approaches. The findings highlight the impact of treatment choice on costs, gross returns, net returns, and the benefit-cost ratio. By optimizing the balance between costs and benefits through well-designed treatment combinations, cultivators can enhance both the profitability and sustainability of sorghum cultivation. These results reinforce the importance of considering economic implications alongside agronomic practices when making cultivation decisions.

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