Effect of Integrated Nutrient Management on Growth, Yield, Nutrient Uptake and Economics,of *Rabi* Sorghum (*Sorghum bicolor*(L.) Moench)

Abstract

A field experiment entitled "Effect of Integrated Nutrient Management on Growth and Yield of *Rabi* Sorghum (*Sorghum bicolor*(L.) Moench) was conducted at post graduate experimental farm of M.S. Swaminathan School of Agriculture, Centurion University of Technology and Management, Paralakhemundi during the rabi season, 2022. The experimental soil was sandy loam with low in available nitrogen and medium in phosphorus and potassium. The experimental design was randomized block design.The experiment consistsof 10 numbers of treatmentsand three replications.The treatments are T_1: Control, T_2: 50% RDF, T_3: 75%RDF, T_4: 100%RDF, T_5: 50%RDF+5t FYM ha^{-1}, T_6: 50% RDF + 10t FYM ha^{-1}, T_7: 75% RDF + 5t FYM ha^{-1}, T_8: 75%RDF+10t FYM ha^{-1}, T_9: 100%RDF + 5t FYM ha^{-1}, T_{10}: 100%RDF + 10t FYM ha^{-1}.Among all the treatments significantly highest growth, yield attributes and nutrient uptake were recorded from the treatment 100%RDF + 10t FYM ha^{-1}(T_{10}). Application of 100%RDF + 10t FYM recorded highest sorghum grain yield (2416 kg ha^{-1}) and gross return (₹ 85108/- ha^{-1}). However, maximum net return (₹ 48010/- ha^{-1})was recorded from 100%RDF + 5t FYM ha^{-1} but B:C ratio (1.49) from 75%RDF.

Keywords:RDF, FYM, sorghum, growth, yield, nutrient uptake, economics

1. Introduction

Sorghum, also known as 'Jowar' in India, which is considered as the most important among all millet crops.It is the fifth most important cereal in the world followed by wheat, rice, maize and barley. Worldwide, sorghum is grown on 40.25 million hectares of land, with an average yield of58.7 million tonnes in 2020 (FAOSTAT, 2022). Whereas, in India in 2020-2021 sorghum production was 4.78 million tonnes from 4.24 million hectares with an average yield of 1128 kg/ha (DES, DA&FW, GoI, 2022). While in Odisha the average yield was too low (633 kg/ha) with the total production of 3.68 thousand tonnes from an area of 5.81 thousand ha in 2019-20(DA&FP, Odisha, 2020). The main sorghum production countries are

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the USA and India. Sorghum is grown under recommended dose of 80kg N, 40kg P_2O_5 and 40kg K_2O per hectare. Integrated use of different sources of plant nutrients such as organic manure and bioinoculants in combination with chemical fertilizers improves soil fertility and crop yield (Ghosh*et al*.,2003). Judicious use of FYM with chemical fertilizers improves soil's physical, chemical, and biological properties and improves crop productivity (Sharma *et al*. 2007).Conventionally, nutrient management in sorghum production has relied heavily on use of chemical fertilizers and often applied in excessive amounts without considering the crop's nutrient needs or the characteristics of the soil. This unbalanced approach has led to nutrient imbalances, reduced soil fertility, increased fertilizer costs, and environmental pollution through nutrient runoff and leaching.Application of FYM andinorganic nitrogen levels recorded higher grain and fodder yield in sorghum fields (Shinde *et al.*,2001).The basic concept behind integrated nutrient management INM is to keep soil fertility high by using all accessible sources of fertilizer. The amount of organic matter in soil affects the nutrients that are available to plants for nutrient uptake (Sarkar, 2005).The present experiment was conducted to study the impact of integrated nutrient management on growth, yield and economics of sorghum.

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2. Materials and method

A field experiment was conducted at Post Graduate research farm ofMSSoA, Centurion University of Technology and Management, Paralakhemundi ($23^0$39 N latitude and $87^0$42` E Longitude) to study the effect of integrated nutrient management on the growth and yield of rabi sorghum. Meteorological data recorded during the crop period has been mentioned in Fig 1.Initial soil analysis had been done before sowing. The soil of the experimental site was sandy loam, acidic in reaction with pH 6.4, medium in organic carbon 0.3%, deficient in nitrogen (228kg ha^{-1}) low in phosphorus (14 kg ha^{-1}), and medium in potassium (120 kg ha^{-1}). The experiment was laid out in randomized block design (RBD)with 10 treatments and each treatment was replicated thrice.The treatments are T_1: Control, T_2: 50% RDF, T_3: 75%RDF, T_4: 100%RDF, T_5: 50%RDF+5t FYM ha^{-1}, T_6: 50% RDF + 10t FYM ha^{-1}, T_7: 75% RDF+5t FYM ha^{-1}, T_8: 75%RDF+10t FYM ha^{-1}, T_9: 100%RDF + 5t FYM ha^{-1}, T_{10}: 100%RDF+10t FYM ha^{-1}. The recommended doses of fertilizer were applied through urea, SSP, and MOP. Urea application was done at two splits, one as basal and another astop dressing at 30 DAS. Sorghum (SSG 59-3) was sown in rabi with the spacing 45 cm x 15 cm and seed rate 8 kg ha^{-1}. The growth attributes and yield attributesas per the schedule period were recorded. After harvesting the crop yield and economics was calculated. The data were analysed statistically

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by the analysis of variance (ANOVA)in MS excel 2010 and the significance of different sources of variation were tested by EMS and F-test at 5% probability.

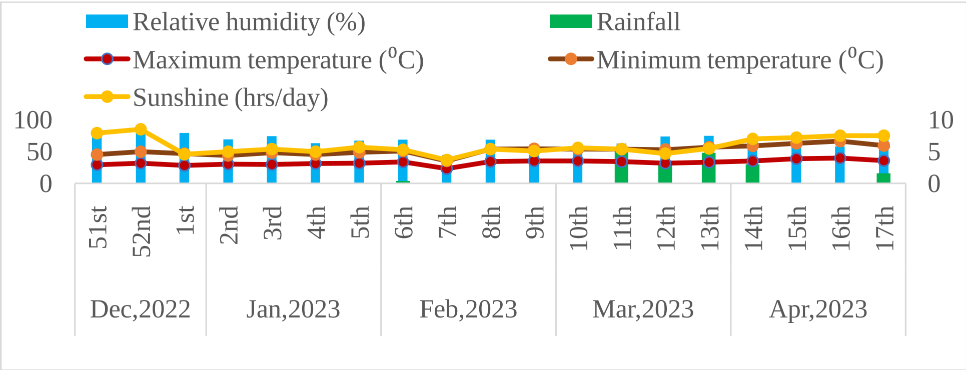

Fig. 1: Graph on meteorological data recorded duringthe crop period

3. Results and discussion

3.1 Growth attributes

Growth attributes of sorghum such as plant height, no. of leaves plant^{-1}, plant dry matter accumulation, leaf area index and stem girth at 90 DAS were mentioned in Table 1. The treatment T_{10}: 100%RDF+10t FYM ha^{-1}recorded significantly highest plant height (250.8cm), no. of leaves plant^{-1}(9.0), plant dry matter accumulation (564 g m^{-2}), leaf area index (2.88) and stem girth (4.1cm) which was also showed significantly at par with the treatments viz. T_9: 100%RDF+ 5t FYM ha^{-1},T_8: 75%RDF+ 10t FYM ha^{-1}and T_4:100% RDF for all the above parameters. Whereas, in case of plant height and no. of leaves plant^{-1} T_{10}: 100%RDF+10t FYM ha^{-1} also remained on par with T_7: 75%RDF+5t FYM ha^{-1}. But the data showed in leaf area index indicated that T_{10} also statistically at par with T_7: 75%RDF+5t FYM ha^{-1}, T_6: 50%RDF+10t FYM ha^{-1} and T_3: 75% RDF. However, significantly lowest growth attributes recorded from T_1: Control (where no nutrient application was done). Higher plant height, no. of leaves plant^{-1}, stem girth and LAI in T_{10} also resulted higher plant dry matter accumulation in T_{10}. Sorghum is a very susceptible and nitro-positive crop. So, the increase of fertilizer level and FYM level increases the height of the plant. Similar results showed that application of 100% recommended dose of fertilizer (RDF) significantly increased plant height than by using 75% or 50% RDF and applying 10 tons of FYM ha^{-1} (Kushwaha *et al.*, 2014). The combination of organics and inorganics will boost the leaf number of plants, this concept was mentioned bySher *et al*. (2022), Sabhad*et al*. (2020) and Afzal *et al*. (2011). Combination of fertilizer and FYM might be provided optimum nutrient

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to plants by modifying soil and plant environment suitable for better performance of plant morphology as well as physiology, which resulted overall crop growth (Priya *et al.*, 2014).

Table 1. Effect of integrated nutrient management on growth attributes of rabi sorghum

Treatments	Plant height (cm)	No. of leaves plant^{-1}	Dry matter accumulation (g m^{-2})	LAI	Stem girth(cm)
T_1: Control	140.5	7.0	382	2.13	2.7
T_2: 50% RDF	194.9	7.3	352	2.26	2.9
T_3: 75% RDF	207.2	7.2	445	2.56	3.2
T_4:100% RDF	245.2	8.5	508	2.69	3.6
T_5: 50%RDF+ 5t FYM ha^{-1}	198.6	7.4	435	2.48	3.0
T_6: 50%RDF+10t FYM ha^{-1}	200.7	7.9	470	2.62	3.3
T_7: 75%RDF+5t FYM ha^{-1}	243.2	8.4	504	2.63	3.4
T_8: 75%RDF+ 10t FYM ha^{-1}	246.5	8.7	516	2.76	3.6
T_9: 100%RDF+ 5t FYM ha^{-1}	248.6	8.8	544	2.83	3.9
T_{10}: 100%RDF+10t FYM ha^{-1}	250.8	9.0	564	2.88	4.1
S. Em. (±)	14.2	0.3	19.27	0.14	0.17
C. D. (P=0.05)	42.8	0.9	57	0.4	0.5

at 90 DAS

3.2 Yield attributes

After the sorghum crop was harvested, yield parameters viz., number of earhead plant^{-1}, length of earhead plant^{-1}(cm), dry weight of earhead(g), grain weight earhead^{-1}(g), and test weight(g) were recorded and presented in Table 2.Effect of integrated nutrient management (INM) significantly influenced yield attributes of rabi sorghum such as no. of ear head plant^{-1}, length of ear head, dry weight of ear head and grain weight ear head^{-1}. Whereas, weight of 1000 seeds (test weight) were not influenced by treatments of INM. Among all the treatments significantly highest no. of ear head plant^{-1} (1.67), length of ear head (35.7cm), dry weight of ear head (40.4g) and grain weight ear head^{-1} (33.6g) were recorded from T_{10} (100%RDF+10t FYM ha^{-1}). Whereas T_1 (control) resulted lowest value of all the parameters. In case of length of ear head plant^{-1} and grain weight ear head^{-1} the treatment T_{10} was statistically at par with T_4, T_6, T_7, T_8 and T_9. The data on no. of ear head plan^{t-1} showed that T_{10} was statistically on par with T_4, T_8 and T_9 but the data on dry weight of ear head showed that T_{10} was statistically at par with only T_9. Additional supply of FYM with 75% RDF and 100% RDF recorded higher yield attributes, which might be due to better nutrient supply through organic and inorganic sources for long period that affects crop growth and photosynthetic activity (Tomar *et al*., (2017).

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Table 2. Effect of integrated nutrient management onyield attributes of rabi sorghum

Treatments	Yield Attributes				
	Number of earheadplant^{-1}	**Length of earhead plant^{-1} (cm)**	**Dry weight of earhead (g)**	**Grain weightear head^{-1} (g)**	**Test weight (g)**
T_1: Control	1.04	27.9	21.0	17.5	9.9
T_2: 50% RDF	1.18	31.0	30.2	27.1	10.5
T_3: 75% RDF	1.24	31.3	32.2	27.9	10.4
T_4 :100% RDF	1.47	34.5	34.5	30.9	10.5
T_5: 50%RDF+ 5t FYM ha^{-1}	1.22	31.2	32.3	28.0	10.5
T_6: 50%RDF+10t FYM ha^{-1}	1.31	31.5	32.4	28.4	10.5
T_7: 75%RDF+5t FYM ha^{-1}	1.44	34.2	33.4	30.7	10.5
T_8: 75%RDF+ 10t FYM ha^{-1}	1.48	34.7	34.8	31.3	10.5
T_9: 100%RDF+ 5t FYM ha^{-1}	1.51	35.2	36.7	31.9	10.5
T_{10}: 100%RDF+10t FYM ha^{-1}	1.67	35.7	40.4	33.6	11.2
S. Em. (±)	0.09	1.4	1.3	1.7	0.23
C. D. (P=0.05)	0.2	4.2	3.8	5.1	NS

3.3. Yield

The grain yield, stoveryieldand harvest index are presented in Table 3. The highest grain yield was recorded from 100%RDF+10t FYM ha^{-1}(T_{10}) which was statistically at par with 100%RDF+5t FYM ha^{-1} (T_9), 75%RDF+10t FYM ha^{-1} (T_8), 75%RDF+5t FYM ha^{-1} (T_7) and 100%RDF ha^{-1} (T_4). With the application of extra 10 t FYM in a hectare there was increase in 7.2% grain yield in the treatment 100%RDF+10t FYM ha^{-1}(T_{10}) over 100%RDF. This shows that addition of FYM with RDF has effect on improving sorghum yield. Similar findings are also recorded by Raja *et al*., (2010). The lowest grain yield was recorded from the control(T_1) where no nutrient application was done. The highest stover yield was found from the T_{10} and T_{10} was statistically remained on par with the treatments viz., T_3, T_4, T_7, T8 and T_9. The lowest stover yield was obtained from the control treatment(T_1) where no nutrient application has done. Harvest index of sorghum was not influenced significantly by the different treatments of integrated nutrient management. The beneficial effect of 100%RDF along with FYM might be associated with sufficient availability of nutrients throughout the growth period especially during critical growth stages, which resulted vigorous growth and yield attributes that ultimately resulted better yield (Jat *et al*., 2014).

Table 3. Effect of integrated nutrient management on yield of rabi sorghum.

Treatments	Yield (kg ha^{-1})		
	Grain	Stover	Harvest index (HI)
T_1: Control	978	2449	28
T_2: 50% RDF	1950	4313	31
T_3: 75% RDF	2103	4952	30
T_4 :100% RDF	2242	5065	31
T_5: 50%RDF+ 5t FYM ha^{-1}	2086	4760	30
T_6: 50%RDF+10t FYM ha^{-1}	2172	4879	31
T_7: 75%RDF+5t FYM ha^{-1}	2240	4993	31
T_8: 75%RDF+ 10t FYM ha^{-1}	2252	5198	30
T_9: 100%RDF+ 5t FYM ha^{-1}	2358	5469	30
T_{10}: 100%RDF+10t FYM ha^{-1}	2416	5493	31
S. Em. (±)	82.96	190.37	1
C. D. (P=0.05)	242	545	NS

3.4 Nutrient uptake

The data on total nutrient uptake (N, P and K uptake) of sorghum is presented in Fig. 2. Total N (168 kg ha^{-1}), P (17.5 kg ha^{-1}) and K (98 kg ha^{-1}) uptake of sorghum were recorded significantly highest from the treatment 100%RDF+10t FYM ha^{-1}(T_{10}) and all the values are lowest in T_1 (Control).

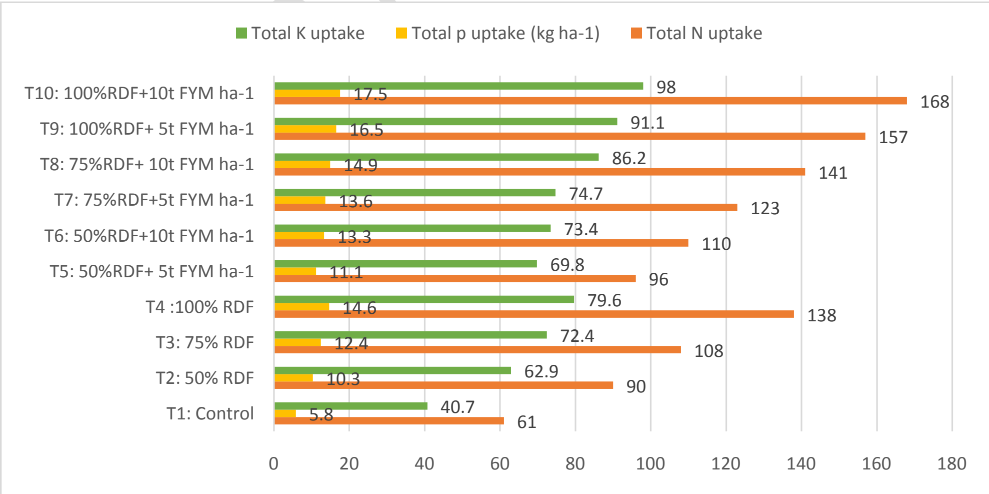

Fig. 2: Effect of integrated nutrient management on total nutrient uptake of rabi sorghum.

Whereas, total N uptake showed that T_{10} is statistically at par with T_9. But total P uptake showed that T_9, T_8 and T_4 were statistically significant with highest recorded treatment T_{10}. Though fertilizer supplies plant nutrient quickly, but judicious and combined application of both fertilizer and FYM might be improved soil microbial activity, which helped in better root proliferation as well as increased different plant nutrient availability. This might be the reason for higher biomass production and nutrient uptake in 100%RDF+10t FYM ha^{-1}. Similar results also found by Tomar *et al*., (2017).

3.5 Economics

Cost of cultivation, gross return, net return and benefit: cost ratio of sorghum for different treatments has been calculated and presented in Table 4.The cost of cultivation (Rs. 37665/- ha^{-1}) and gross return (Rs. 85108/- ha^{-1}) of sorghumwere highest in the treatment 100%RDF+10t FYM ha^{-1} (T_{10}) due to higher application of fertilizer and FYM. Moreover, in terms of benefit-cost ratio, the highest (1.53) results were obtained with the application of 100% RDF and in terms of net returns the highest (Rs. 48010/- ha^{-1}) value was obtained with the application of 100%RDF+ 5t FYM ha^{-1}. Application of higher quantity of FYM increased cost of cultivation and decreased benefit: cost ratio in treatments where RDF and FYM applied combinedly. But due to high yield and 5t less FYM application resulted maximum net return from the treatment 100%RDF+ 5t FYM ha^{-1} (T_9). In line with the above result Tomar *et al*. (2017) reported that application of 75%NPK + 5t FYM ha^{-1}in maize recorded higher net return (Rs. 29634/- ha^{-1}) and lower B:C ratio (2.57) as compared to the treatment 75%NPK, Rs. 27789/- ha^{-1} and 2.62 respectively in 2011.

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Table 4. Effect of integrated nutrient management on economics of *rabi* sorghum.

Treatments	Economics			
	Cost of cultivation (Rs. ha^{-1})	**Gross return (Rs. ha^{-1})**	**Net return (Rs. ha^{-1})**	**B:C ratio**
T_1: Control	23755	35711	11956	0.50
T_2: 50% RDF	28560	68653	40093	1.40
T_3: 75% RDF	29915	74364	44449	1.49
T_4 :100% RDF	31265	78991	47726	1.53
T_5: 50%RDF+ 5t FYM ha^{-1}	32460	73587	41127	1.27
T_6: 50%RDF+10t FYM ha^{-1}	34960	76654	41694	1.19
T_7: 75%RDF+5t FYM ha^{-1}	33815	79392	45577	1.35
T_8: 75%RDF+ 10t FYM ha^{-1}	36315	79728	43413	1.20
T_9: 100%RDF+ 5t FYM ha^{-1}	35165	83175	48010	1.37
T_{10}: 100%RDF+10t FYM ha^{-1}	37665	85108	47443	1.26

4. **Conclusion**

Integrated Nutrient Management plays a crucial role in well growth and development of sorghum plants. By incorporating the recommended doses of fertilizers and farm yard manure, farmers can promote balanced nutrition, enhance soil fertility, and improve overall plant growth. However, it is important to consider other agronomic practices and environmental factors that influence plant growth for successful sorghum production. It should be emphasised that although utilising simply 100% RDF of inorganic fertilisers would improve benefit-cost ratio, but considering the net return, soil health, environmental well-being and sustainability taking into account the integrated strategy of applying 100% RDF+5t FYM ha^{-1} would be advantageous.

References

1. Afzal M, Ahamad A, Ahamad AH (2011). Effect of nitrogen on growth and yield of Sorghum forage under three cutting system. CercetariAgronomice in Moldova.**45**(4):152.

2. Agricultural statistics at a glance. 2021. Department of Agriculture, Cooperation & Farmers Welfare. Directorate of Economics & Statistics, Government of India. https://eands.dacnet.nic.in/PDF/Agricultural%20Statistics%20at%20a%20Glance%20-%202020%20(English%20version).pdf (Accessed on 2nd November 2022.

3. FAOSTAT. 2022. Crop Statistics. http://www.fao.org/faostat/en/#data/QCL (Accessed on 2nd November 2022).

4. Five Decades of Odisha Agriculture Statistics. 2020. Directorate of agriculture and foodproduction,Odisha.http://agriodisha.nic.in/content/pdf/Five%20Decades%20of%20Odisha%20Agriculture%20Statistics.pdf (Accessed on 2nd September 2021).

5. Ghosh PK, Bandyopadhyay, TripathiAK, Hati KM, Mandal KG, Mishra AK (2003). Effect of integrated management of farmyard manure, phosphocompost, poultry manure, and inorganic fertilizer for rain-fed sorghum (*sorghum bicolor*) in vertisol of central India. *Indian J. Agron*.**48**: 48-52.
6. Jat MK, Purohit HS, Singh B, Garhwal RS, Choudhary M (2013). Effect of integrated nutrient management on yield and nutrient uptake in sorghum (Sorghum bicolor). *Indian J. Agron.* **58**(4): 543-547.

7. Priya S, Kaushik MK, Sharma SK, Priyanka K (2014). Impact of integrated nutrient management on growth and productivity of hybrid maize (*Zea mays* L.). *AnnBiol*. **30**(1): 106-108.
8. Raja W, Khanday BA, Haq A (2010). Integrated nutrient management in rice (Oryza sativa L.) *Res.J.Agric. Sci*. **1**:150-152
9. Sabhad HV, Sakarvadia HL, Hirpara DV, Jadeja AS, Vekaria LC (2020). Influence of cadmium and FYM on growth, yield and quality of fodder sorghum. *Int. J.Conserv. Sci*. **8**(6): 546-549.
10. SarkarAK (2005). Managing natural resources for increasing agricultural production in eastern India. *J. Indian Soc. soil Sci*. **53**: 435-437
11. Sharma A, Singh H,Nanwal RK (2007). Effect (*Triticumaestivum*) under limited and adequate irrigation supplies.*Indian J. Agron*. 52: 120-123.
12. Sher A, Adnan M, Sattar A, Ul-Allah S, Ijaz M, Hassan MU, El Askary A (2022). Combined application of organic and inorganic amendments improved the yield and nutritional quality of forage sorghum. *Agron.* **12**(4): 896.
13. Shinde GG, Deshpande PM, Lomte MH, Deshmukh AS, Algave BN (2001). Yield maximization of irrigated rabi sorghum. International Sorghum and Millets Newsletter. **42**: 31-34.
14. Tomar SS, Singh A, Dwivedi A, Sharma R, Naresh RK, Kumar V, Singh BP (2017). Effect of integrated nutrient management for sustainable production system of maize (Zea mays L.) in indo-gangetic plain zone of India. *Int. J. Chem. Stud*. **5**(2), 310-316.

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