International Journal of Agriculture, Environment and Biotechnology
Citation: IJAEB: 12(3): 273-279, September 2019
DOI: 10.30954/0974-1712.08.2019.11

AGRONOMY

Effect of Integrated Nutrient Management on Productivity, Nutrient Uptake and Economics of Finger Millet (*Eleusine coracana* L. Gaertn)

J.V. Harika*, Sagar Maitra, Tanmoy Shankar, Monisankar Bera and Pilli Manasa

Department of Agronomy, M.S. Swaminathan School of Agriculture, Centurion University of Technology and Management, Paralakhemundi-761 211, India

*Corresponding author: harikavania@gmail.com (**ORCID ID**: 0000-0001-9009-3041)

Paper No. 792 **Received:** 05-04-2019 **Revised:** 12-07-2019 **Accepted:** 21-08-2019

ABSTRACT

A field experiment was conducted during *kharif* season of 2018 at Bagusala Farm, of M.S. Swaminathan School of Agriculture, Centurion University of Technology Management, Paralakhemundi, Odisha to study the effect of integrated nutrient management in finger millet (*Eleusine coracana* L. Gaertn) on yield attributes, productivity and nutrient uptake under south Odisha conditions. The experiment was laid out in randomized complete block design with ten treatments and replicated thrice. The treatment combinations are T_1, control,T_2, FYM @ 4 t ha^{-1}, T_3 FYM @ 8 t ha^{-1}, T_4, 100% RDF (40:20:20 - N: P_2O_5: K_2O kg ha^{-1}), T_5, 50% RDF + 4 t FYM, T_6, 75% RDF + 2 t FYM, T_7, FYM 4 t ha^{-1}+ *Azospirillum* @ 5 kg ha^{-1}, T_8, FYM 8 t ha^{-1} + *Azospirillum* @ 5 kg ha^{-1}, T_9, 50% RDF + 4 t FYM + *Azospirillum* @ 5 kg ha^{-1}, T_{10}, 75% RDF + 2 t FYM + *Azospirillum* @ 5 kg ha^{-1}. Application of 100% RDF resulted in the highest yield components like number of effective tillers m^{-2}, number of grains ear head^{-1}, number of fingers ear head^{-1}, test weight and length of fingers which remained statistically at par with the application of chemical fertilizers along with the FYM and *Azospirillum* (T_{10}). The highest grain yield, straw yield and biological yield were achieved from the treatment with 100% RDF which was followed by application of 75% RDF + 2 t FYM + *Azospirillum* (T_{10}) and 75% RDF + 2 t FYM (T_6). However, the lowest values yield attributes and yields were recorded in control (no nutrients). Total nutrient (NPK) uptake by finger millet differed and it was found that application of 100% RDF recorded significantly higher nutrient uptake than other treatments. The lowest uptake of N, P and K was recorded in absolute control treatment.

Highlights

- Application of 100% RDF and Integrated Nutrient Management (INM) are beneficial in enhancement of yield attributes and yield of finger millet along with N, P, K uptake by the crop.

Keywords: Integrated nutrient management, finger millet, FYM, *Azospirillum*

India is the largest producer of various kinds of millets. Out of the total minor millets produced finger millet (*Eleusine coracana L.* Gaertn) accounts for about 85% of production in India (Sakamma *et al.* 2018). It is grown in India, Sri Lanka, Nepal, Madgaskar, Malaysia, Uganda and Japan. Finger millet is an important small millet crop grown in India the highest productivity amongst small millets. It is commonly known as 'nutritious millet' as the grain is nutritionally superior to many cereals. Qualities like wide adaptation, easy cultivation, free from major pests and diseases and drought tolerance have made this crop an automatic choice in dry farming system. Often in the lands where finger millet crop is raised, no other worth mentioning crop can give a reasonable harvest (AICSMIP, 2013). In addition, being a member of C4 group of plants, finger millet sequesters carbon, thereby adding CO_2 abatement opportunity, which is also ecologically beneficial (Brahmachari *et al.* 2018). In India, finger millet is cultivated mainly in the states like Karnataka, Tamil Nadu, Andhra Pradesh, Orissa, Jharkhand, Uttaranchal, Maharashtra, and Gujarat. In India, finger millet is cultivated over an area of 1.27 million hectares with a production of 2.61 million tonne giving an average productivity of 1489 kg ha^{-1} (Agriculture Statistics at a Glance, 2017).

MATERIALS AND METHODS

The field experiment was conducted at Bagusala Farm, of M.S. Swaminathan School of Agriculture, Centurion University of Technology Management, Paralakhemundi, Gajapati, Odisha, which is geographically located at 23°39′ N latitude and 87°42′ E longitude under tropical climatic conditions. Sowing of finger millet crop coincided with sufficient rain (1047.6 mm) occurred during the year 2018. During the crop period the mean maximum temperature varied between 30.1°C to 45.8°C with an average of 34.6°C whereas the weekly mean minimum temperature during this crop period ranged from 21.4°C to 27.5°C which an average of 25.6°C. The experimental soil was sandy loam in texture, neutral in soil reaction (pH 6.5), medium in organic carbon (0.50%), low in available nitrogen (104 kg ha^{-1}), medium in available phosphorus (23 kg ha^{-1}) and medium in available potassium (196 kg ha^{-1}). The experiment was laid out in a randomized complete block design (RCBD) with ten treatments and three replications. The spacing row to row and plant to plant distance 20 cm × 20 cm adopting square planting method and the plot size was 4 m x 3 m. The treatments were: T_1, control, T_2, FYM @ 4 t ha^{-1},T_3 FYM @ 8 t ha^{-1}, T_4, 100% RDF (40:20:20 kg ha^{-1} of N: P_2O_5: K_2O), T_5, 50% RDF + 4 t FYM, T_6, 75% RDF + 2 t FYM, T_7, FYM 4 t ha^{-1}+ *Azospirillum* @ 5 kg ha^{-1}, T_8, FYM 8 t ha^{-1} + *Azospirillum*@ 5 kg ha^{-1}, T_9, 50% RDF + 4 t FYM + *Azospirillum* @ 5 kg ha^{-1}, T_{10}, 75% RDF + 2 t FYM + *Azospirillum* @ 5 kg ha^{-1}. The farm yard manure was analysed for its nitrogen content and applied accordingly as per the treatments and it was thoroughly incorporated into the soil 15 days prior to transplanting of crop. The recommended dose of chemical N, P_2O_5 and K_2O were supplied through different sources like urea, single super phosphate and muriate of potash respectively as per the treatments. The entire quantity of phosphorus and potassium and half of the nitrogen were applied as basal at the time of transplanting. The remaining quantity of nitrogen was applied as top dressing at 21 days after transplanting. The *Azospirillium* slurry was prepared and the seedlings for the respective treatments were treated by root dipping for 30 minutes prior to transplanting. Though it was a rainfed crop, however, two life-saving irrigations were given on 17 and 42 DAT. The data recorded on various parameters of crop were subjected to statistical scrutiny by the method of analysis of variance as outlined by Panse and Sukhatme (1985) and presented.

RESULTS AND DISCUSSION

Yield attributes

The data on yield attributes recorded, viz., number of effective tillers m^{-2}, number of grains ear $head^{-1}$, number of fingers ear $head^{-1}$, test weight and length of finger were analyzed statistically and presented in Table 1.The data on effective tillers m^{-2} revealed that there was significant difference among nutrient management treatments. The treatment T_4 (100% RDF) produced the maximum number of effective tillers m^{-2} (34.6) which was significantly superior to all other treatments except T_{10} (75% RDF + 2 t FYM + *Azospirillum* @ 5 kg ha^{-1}). The treatment T_1 (control) registered the lowest value in terms of production of effective tillers m^{-2} which was statistically at par with some of the treatments like T_2 (FYM 4t ha^{-1} and T_3 (FYM 8t ha^{-1}). Further combined application of 50% RDF + 4 t FYM + *Azospirillum* @ 5 kg ha^{-1} (T_9) and 75% RDF + 2 t FYM + *Azospirillum* @ 5 kg ha^{-1} (T_{10}) recorded significantly a greater number of effective tillers than control. Similar result was observed in the **n**umber of grains ear $head^{-1}$ (Table 1). The treatment with 100% RDF (T_4) resulted in production of maximum number of grains ear $head^{-1}$ (1545) and it was significantly superior to all other treatments. The production of number of fingers ear $head^{-1}$ was significantly influenced by the nutrient management treatments which registered the highest value (8.6) in treatment T_4 (100% RDF) which was closely followed by T_6 (75% RDF + 2 t FYM), T_9 (50% RDF + 4 t FYM + *Azospirillum* @ 5 kg ha^{-1}) and T_{10} (75% RDF + 2 t FYM + *Azospirillum* @ 5 kg ha^{-1}) and these treatments remained statistically at par. But T_4 (100% RDF) exhibited its significant

Table 1: Yield attributes of finger millet as influenced by integrated nutrient management

Treatments	Yield attributes				
	Effective tillers m^{-2}	Number of grains ear $head^{-1}$	Number of fingers ear $head^{-1}$	Test weight (g)	Length of finger (cm)
T_1 Control (no fertilizer)	19.8	1372	6.8	2.35	10.6
T_2 FYM 4 t ha^{-1}	20.2	1378	6.9	2.35	10.6
T_3 FYM 8 t ha^{-1}	20.2	1381	6.9	2.36	10.9
T_4 100% RDF	34.6	1545	8.6	2.59	12.1
T_5 50% RDF + 4 t FYM	26.4	1420	8.0	2.44	11.4
T_6 75% RDF + 2 t FYM	31.5	1478	8.3	2.54	11.1
T_7 FYM 4 t ha^{-1}+ *Azospirillum*	21.6	1384	7.4	2.37	11.5
T_8 FYM 8 t ha^{-1} + *Azospirillum*	22.0	1390	7.5	2.39	11.5
T_9 50%RDF + 4 t FYM +*Azospirillum*	27.1	1433	8.5	2.54	11.8
T_{10} 75% RDF + 2 t FYM + *Azospirillum*	32.4	1502	8.5	2.55	12.1
SEm ±	0.73	32.0	0.19	0.05	0.27
CD (P= 0.05)	2.18	95.1	0.58	NS	NS
CV (%)	8.6	6.7	7.6	6.1	7.2

superiority to T_1 (control), T_2 (FYM 4t ha^{-1}) and T_3 (FYM 8t ha^{-1}). The test weight and length of finger of the finger millet also followed a trend similar to that obtained with other yield attributes, these two characters did not vary significantly among the different treatments under the study. The results clearly indicated that test weight was a very stable character and much variation by different nutrient management practices was not observed. Use of 100% RDF through chemical fertilizers was found most conducive nutrient management practice in finger millet that greatly influenced number of effective tillers compared to other treatments. The results corroborate with the findings of Giribabu *et al*. (2010), Lakshmipathi (2012), Raman *et al*. (2016), Apoorva *et al*. (2010).

Yield

The Observation on grain yield, straw yield, biological yield harvest index and total nutrient uptake was recorded and presented in Table 2. The data clearly revealed that grain, straw yield biological yield of finger millet was influenced significantly by different nutrient management treatments. Application of 100% RDF (T_4) resulted in maximum grain yield (1412 kg ha^{-1}), straw yield (4532 kg ha^{-1}) and biological yield (5944 kg ha^{-1}), however, the treatment was significantly superior to all other treatments. Further, it was noted that the treatments with 75% RDF and 50% RDF along with combination of organic manure and biofertilizer recorded grain, straw and biological yield of finger millet significantly over control. The results clearly indicated that the requirement of sufficient nutrients for enhancement of productivity. However, the maximum value of harvest index (23.7) was noted with T_4 (100% RDF) which was followed by T_{10} (75% RDF + 2 t FYM + *Azospirillum* @ 5 kg ha^{-1}) and the least value was noted with control (T_1). The crop nutrients particularly nitrogen at flowering stage expectedly resulted in relatively higher nitrogen accumulation in foliage including lower leaves, contributing to higher growth and cytokinin production that in turn control senescence of the whole plant causing more dry matter production to meet the needs of larger sink in finger millet. Application of only FYM did not show much influence in terms of grain yield, probably because of organic manures are slow release in nature and might be the entire nutrient would not be released in the crop cycle and it might be benefited to the succeeding crop. Similarly, biofertilizers in combination with organic manures are known to improve the soil fertility and thus enhance productivity. The results corroborate the findings of Kumara *et al*. (2007), Basavaraju and Purushotham (2009), AICRPDA (2011), Patil *et al*. (2015) and Roy *et al.* (2018).

Uptake of Nutrients

The maximum uptake of nitrogen, phosphorus and potassium by the finger millet (35.2 kg ha^{-1}, 19.5 kg

Table 2: Yield and nutrient uptake of finger millet as influenced by integrated nutrient management

Treatments	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Harvest index	Total N uptake (kg ha^{-1})	Total P uptake (kg ha^{-1})	Total K uptake (kg ha^{-1})
T_1-Control (no fertilizer)	637	2267	2904	21.9	15.77	8.69	32.64
T_2-FYM 4 t ha^{-1}	648	2280	2928	22.1	15.95	8.78	32.87
T_3- FYM 8 t ha^{-1}	661	2320	2981	22.1	16.31	9.20	33.74
T_4 -100% RDF	1412	4532	5944	23.7	35.26	19.54	67.62
T_5-50% RDF + 4 t FYM	932	3178	4110	22.6	23.40	13.05	46.67
T_6-75% RDF + 2 t FYM	1176	3951	5127	22.9	29.73	16.30	58.08
T_7- FYM 4 t ha^{-1}+ *Azospirillum*	702	2450	3152	22.0	17.55	9.75	35.65
T_8- FYM 8 t ha^{-1} + *Azospirillum*	731	2536	3087	23.7	18.06	10.13	37.15
T_9-50%RDF + 4 t FYM +*Azospirillum*	948	3204	4152	22.8	24.13	13.63	48.53
T_{-10} 75% RDF + 2 t FYM + *Azospirillum*	1191	3882	5073	23.4	29.96	16.66	57.83
SEm±	26	55	93	0.65	0.61	0.32	1.19
CD (P= 0.05)	78	162	277	NS	1.82	0.95	3.54
CV (%)	8.8	5.4	7.1	8.7	8.1	7.6	7.9

Table 3: Economics of finger millet as influenced by integrated nutrient management

Treatments	Cost of cultivation (₹ ha^{-1})	Gross returns (₹ ha^{-1})	Net returns (₹ ha^{-1})	B:C ratio
T_1 Control (no fertilizer)	17640	16637	-1003	-0.05
T_2 FYM 4 t ha^{-1}	20440	16872	-3568	-0.17
T_3 FYM 8 t ha^{-1}	23240	17199	-6041	-0.25
T_4 100% RDF	20278	35946	15668	0.77
T_5 50% RDF + 4 t FYM	21759	24064	2305	0.10
T_6 75% RDF + 2 t FYM	21018	30246	9228	0.43
T_7 FYM 4 t ha^{-1}+ *Azospirillum*	21190	18238	-2952	-0.13
T_8 FYM 8 t ha^{-1} + *Azospirillum*	23990	18961	-5029	-0.20
T_9 50% RDF + 4 t FYM +*Azospirillum*	22509	24420	1911	0.08
T_{10} 75% RDF + 2 t FYM + *Azospirillum*	21768	30393	8625	0.39

ha^{-1} and 67.6 kg ha^{-1} respectively) was noticed with 100% RDF (T_4) which was significantly higher than other treatments. The control (T_1) treatment recorded the lowest uptake of nutrients (15.7 kg ha^{-1}, 8.6 kg ha^{-1} and 32.6 kg ha^{-1} of N, P and K respectively) by finger millet. Uptake of any nutrient is the function of its content and dry matter production by the crop. Higher nutrient content in the produce and higher biomass production of finger millet might be the pertinent reason for higher uptake of nutrients. These findings are in close agreement with the results reported by Raman and Krishnaprabu (2004), Jagadeesha (2009), Jagathjothi *et al.* (2010), Arulmozhiselvan *et al.* (2013), Ramakrishnan and Bhuvaneswari (2014).

Economics

The highest cost of cultivation (₹ 23990 ha^{-1}) was recorded with treatment T_8 (FYM 8 t ha^{-1} + *Azospirillum* @ 5 kg ha^{-1}) because of higher amount utilization of FYM and *Azospirillum* and it is followed by T_3 (FYM 8t ha^{-1}) treatment. Lowest cost of cultivation (₹ 17640 ha^{-1}) recorded with control (T_1) treatment because no nutrients were applied in the treatment. The maximum gross return (₹ 35946 ha^{-1}) of finger millet was obtained with 100% recommended dose of fertilizers (T_4) which was significantly superior to all other treatments. This was due to production of higher grain yield and straw yield. The next higher gross return was obtained with 75% RDF + 2t FYM + *Azospirillum* (T_{10}). Application of 75% RDF+ 2t FYM (T_6) was noticed to be at par with T_{10} (75% RDF + 2t FYM + *Azospirillum*). The lowest gross return (₹ 16637 ha^{-1}) was recorded with control (T_1) treatment due to the lowest grain yield and straw yield. The highest

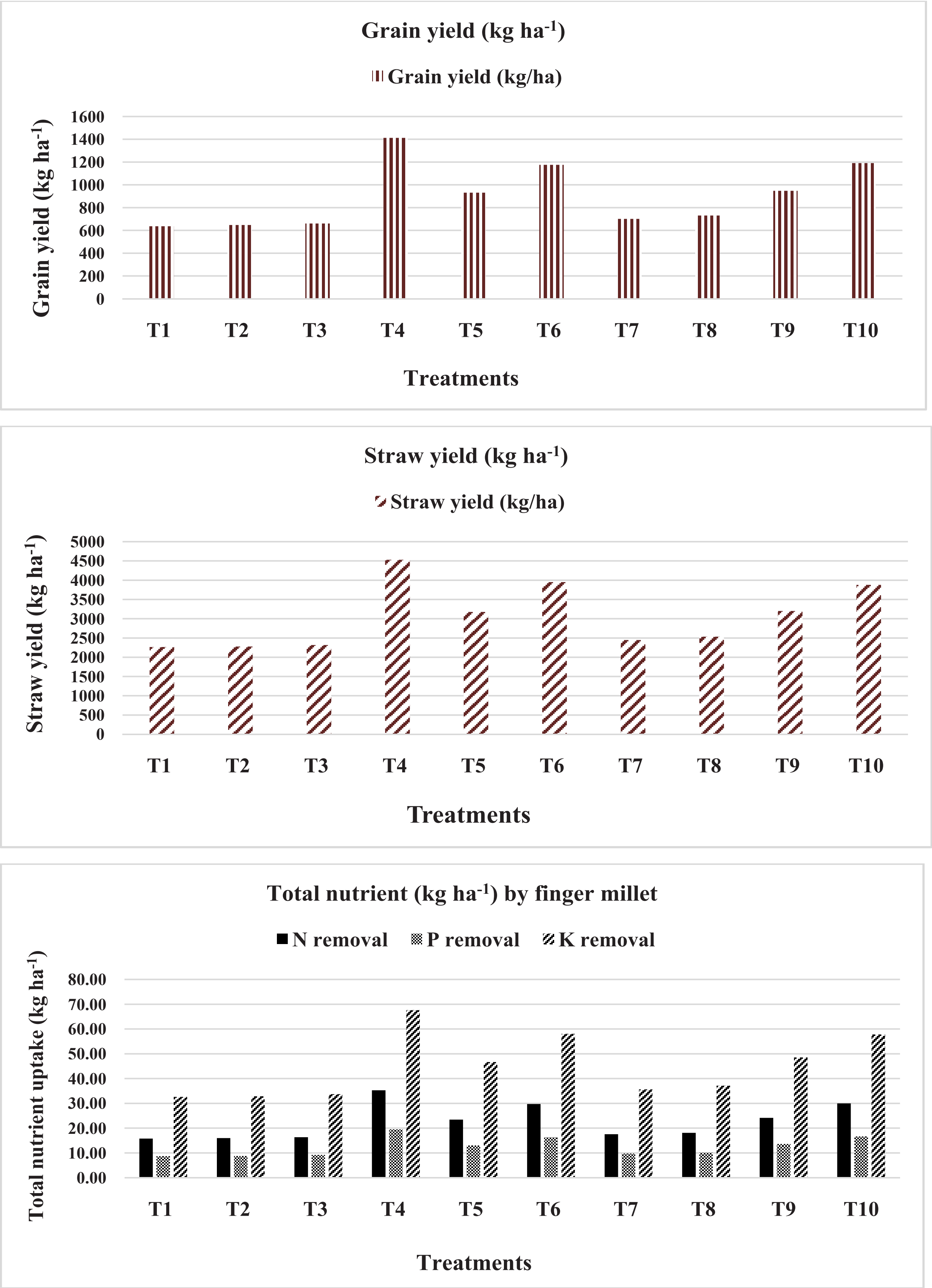
Grain yield (kg ha-1)
Grain yield (kg/ha)
Grain yield (kg ha-1)
1600
1400
1200
1000
800
600
400
200
0
T1 T2 T3 T4 T5 T6 T7 T8 T9 T10
Treatments
Straw yield (kg ha-1)
Straw yield (kg/ha)
Straw yield (kg ha-1)
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
T1 T2 T3 T4 T5 T6 T7 T8 T9 T10
Treatments
Total nutrient (kg ha-1) by finger millet
N removal
P removal
K removal
Total nutrient uptake (kg ha-1)
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
T1 T2 T3 T4 T5 T6 T7 T8 T9 T10
Treatments

Fig. 1

net return (₹ 15668 ha^{-1}) was realized with 100% recommended dose of fertilizers (T_4), which was significantly higher than rest of the treatments. This might be due to higher grain and straw yield. The next best treatment was 75% RDF + 2 t FYM + *Azospirillum* (T_{10}). The treatment T_3 (FYM 8 t ha^{-1}) recorded the lowest net return (Rs. - 6041 ha^{-1}) due to lowest grain yield and straw yield. The highest benefit: cost ratio (0.77) was registered with 100% recommended dose of fertilizers (T_4) which was significantly superior to all other treatments. The next best treatment was T_{10} (75% RDF+ 2t FYM+ *Azospirillum*). The lowest benefit: cost ratio (-0.25) was registered with T_3 (FYM 8 t ha^{-1}) treatment due to the lowest grain and straw yield associated with more cost of cultivation incurred in purchasing of FYM. The highest gross return and net return as well as benefit: cost ratio realised with 100% recommended dose of fertilizers (T_4) might be due to the higher grain yield and straw yield as well as moderately less cost of cultivation. Among the various integrated nutrient management practices, the higher economic return was obtained with T_{10} (75% RDF+ 2t FYM+ *Azospirillum*). The higher level of biomass accumulation and efficient translocation to the reproductive parts due to supply of adequate nutrients might be responsible for the production of elevated yield attributes, which resulted in higher monetary returns and B:C ratio. Similar results were also reported by Kumara *et al*. (2007), Reddy and Reddy (2010), Patil *et al*. (2015) and Pallavi *et al*. (2016).

CONCLUSION

Based on the study of integrated nutrient management in finger millet it may be concluded that finger millet may be grown in south Odisha conditions during *kharif* season with 100% recommended dose of fertilizers. However, considering the long-term productivity and improvement of soil fertility, the crop may be cultivated with 75% RDF + 2 t FYM + *Azospirillum* @ 5 kg ha^{-1}.

ACKNOWLEDGEMENTS

The authors are grateful to the authority of M.S. Swaminathan School of Agriculture, Centurion University of Technology and Management for funding and necessary support to carry out the experiment.

DECLARATION

The content is based on the research work carried out by the first author for partial fulfillment of M.Sc. Ag (Agronomy) degree and there is no conflict of interest among the authors.

REFERENCES

Agricultural Statistics at a Glance. 2017. Directorate of Economics and Statistics, Ministry of Agriculture, Government of India.

AICRPDA (All India Coordinated Research Project for Dryland Agriculture) Annual Report 2011-12, GKVK Campus, University of Agricultural Sciences, Bengaluru, Karnataka, pp. 129-130.

Apoorva, K.B., Prakash, S.S., Rajesh, N.L. and Nandini, B. 2010. STCR approach for optimizing integrated plant nutrient supply on growth, yield and economics of finger millet (*Eleusine coracana* L. Gaertn). *European Journal of Biological Science*, **4**(1): 19 - 27.

Basavaraju, T.B. and Purushotham, S. 2009. Integrated nutrient management in rainfed ragi (*Eleusine coracana* L. Gaertn.). *Mysore Journal of Agricultural Sciences*, **43**(2): 366-368.

Giribabu, B. 2006. Productivity and quality of finger millet (*Eleusine coracana* L. Gaertn.) cultivars as affected by nutrient management system. M.Sc. (Ag) Thesis. Acharya N.G Ranga Agricultural University.

Jagathjothi, N., Ramamoorthy, K. and Priya, R.S. 2010. Influence of enriched FYM with inorganic fertilizers on nutrient uptake, available nutrients and productivity of rainfed finger millet. *Madras Agricultural Journal*, **87**(10-12): 385-387.

Brahmachari, Koushik, Sarkar, Sukamal, Santra Dipak, K. and Maitra, Sagar. 2018. Millet for food and nutritional security in drought prone and red laterite region of eastern India. *International Journal of Plant and Soil Science*, **26**(6): 01-07.

Kumara, O., Naik, B.T and Palaiah, P. 2007. Effect of weed management practices and fertility levels on growth and parameters in finger millet. *Karnataka Journal of Agricultural Sciences*, **20(**2): 230-233.

Lakshmipathi, R.N. 2012. Identification of beneficial microflora in liquid organic manures and biocontrol formulations and their influence on growth and yield of finger millet (*Eleusine coracana* L. Gaertin) and field bean (*Dolichos lab lab* L.) M.Sc. (Ag.) Thesis, University of Agricultural Sciences, Bengaluru, Karnataka.

Pallavi, Ch., Joseph, B., Aariff Khan, M.A. and Hemalatha, S. 2016. Economic evaluation of finger millet under different nutrient management practices. *International Journal of Current Microbiology and Applied Sciences*, **5**(8): 690-698.

Panse, V.G. and Sukhatme. 1978. Statistical methods for agricultural workers 3rd edition. Indian Council of Agricultural Research Publication, New Delhi, pp. 361.

Patil, S.V., Bhosale, A.S. and Khambal, P.D. 2015. Effect of various levels of fertilizers on growth and yield of finger millet. *IOSR Journal of Agriculture and Veterinary Science*, **8**: 49-52.

Raman, R. and Krishnaprabu, S. 2004. Effect of integrated nutrient management on nutrient uptake and yield of finger millet. *Journal of Eco Biology*, **16**(3): 197-20.

Reddy, M.J. and Reddy, V.C. 2010. Developing organic package of practices for yield maximization of rainfed finger millet. Annual Programme Report, Research Institute of Organic Farming, University of Agricultural Sciences, Bengaluru, pp. 30-34.

Roy, A.K., Ali, N., Lakra, R.K., Alam, P., Mahapatra, P. and Narayan, R. 2018. Effect of integrated nutrient management practices on nutrient uptake, yield of finger millet (*Eleusine coracana* L. Gaertn.) and post-harvest nutrient availability under rainfed condition of Jharkhand. *International Journal of Current Microbiology and Applied Sciences*, **7**(8): 339-347.

Sakamma, S., Umesh, K.B., Girish, M.R., Ravi, S.C., Satishkumar, M. and Veerabhadrappa Bellundagi. 2018. *Journal of Agricultural Science*, **10**(1): 162-17.