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Effect of Integrated Nutrient Management on Growth and Yield of Finger Millet [*Eleusine coracana* (L.) Gaertn]

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Abstract

A field experiment was conducted in red sandy loam soil at Instructional Farm, College of Agriculture, Padanakkad, Kerala, during the rabi season of 2021-22 to study the effect of different levels of farm yard manure (FYM) and nutrients on the growth and yield of finger millet. The highest values of growth parameters such as plant height, leaf area per hill, number of tillers per hill and dry matter production was obtained by the integrated application of higher level of FYM (10 t ha^{-1}) and nutrients (NPK @ 75:37.5:37.5 kg ha^{-1}). Grain and straw yield was higher with the application of higher nutrient level (NPK @ 75:37.5:37.5 kg ha^{-1}) which was on par with soil test based fertilizer recommendation (SBFR) *i.e.,* NPK @ 41:6:19 kg ha^{-1}. Quality parameters and physiological parameters were also positively influenced by the application of higher nutrient levels. Yield was higher with the integrated application of FYM @ 10 t ha^{-1} + NPK @ 75:37.5:37.5 kg ha^{-1} which was on par with the application of SBFR + FYM @ 5 t ha^{-1}. The highest net returns was also obtained for the treatment wherein the nutrients were supplied through FYM @ 10 t ha^{-1} + NPK @ 75:37.5:37.5 kg ha^{-1}. Integrated application of SBFR + FYM @ 5 t ha^{-1} resulted in significantly higher values of straw yield and benefit cost ratio.

Keywords : Finger millet, FYM, Nutrient levels, Growth, Yield, Economics

Green revolution in India has given key emphasis to the expansion of area and production of cereals which resulted in the decline of millet production and consumption. Millets are good source of minerals like iron, zinc and calcium; they are gluten free and also have low glycaemic index (APEDA, 2020). In order to ensure food security for the younger generations, millets are recognised as a substitute for major cereal crops and Government of India has proposed to declare year 2023 as International Year of Millets (IYM) which was accepted by the United Nations General Assembly (GoI, 2022). In India, the area under finger millet is 12.11 lakh ha with an annual production of 16.96 lakh tonnes and a productivity of 1401 kg ha^{-1} (APEDA, 2020). In Kerala, finger millet is cultivated in an area of 213 ha confined to the districts of Idukki and Palakkad with a total production of 261 tonnes (FIB, 2022).

Ragi contains 9.2 per cent protein, 1.29 per cent fat, 76.32 per cent carbohydrates, 2.2 per cent minerals, 3.90 per cent ash and 0.33 per cent calcium (Sarawale *et al.*, 2017). In the South Indian states of Karnataka, Tamil Nadu and Andhra Pradesh, high yielding fertilizer responsive varieties of finger millet are cultivated with an average yield ranging from 1.0 t ha^{-1} to 3.5 t ha^{-1} and the recommended dose of fertilizer in these states varies from 60:30:30 kg ha^{-1} NPK to 90:45:45 kg NPK ha^{-1} (Jeyaraman, 2014) and higher dose of FYM (10 t ha^{-1}). The Kerala Agricultural University (KAU) *ad hoc* nutrient recommendation for finger millet is 45:22.5:22.5 kg

NPK ha^{-1} and FYM is 5 t ha^{-1}. In Kerala, the integrated nutrient management practice for finger millet has to be standardised with different levels of FYM and nutrients using high yielding varieties as there is scope for increasing the average yield. The demand for finger millet grains and products has been increasing among the urban population and the crop has the ability to come up even in soils of low fertility. Under these circumstances, there is scope for popularising the cultivation of finger millet among the farmers in different districts of Kerala. Several nutrient experiments conducted in finger millet revealed that integrated application of organic manures and chemical fertilizers had crucial role in enhancing the yield of finger millet and improving soil health (Maitra, 2020). Hence, the experiment titled 'Integrated nutrient management of finger millet (*Eleusine coracana* L.) in red sandy loam soil' was conducted with the objective of standardising the integrated nutrient management practices.

Material and Methods

The field experiment was conducted to study the effect of integrated nutrient management practices (INM) on the growth and yield of finger millet during the *rabi* season (2021-22) at Instructional Farm, College of Agriculture, Padanakkad, Kerala. The experimental field was located at 12^{0}14'45" North latitude and 75^{0}8'6" East longitude at an altitude of 9 m above mean sea level. High yielding and blast tolerant finger millet variety KMR-301 was used for the experiment, planted at a spacing of 25×15 cm. Initial status of soil was acidic with pH value of 5.67 and was of red sandy loam in texture.

The experiment was carried out in factorial Randomized Block Design (FRBD) with 10 treatments replicated three times. Factor A consisted of two levels of farm yard manure (FYM) *i.e.,* 5 t ha^{-1} (A_1) and 10 t ha^{-1} (A_2). Factor B comprised of five different levels of nutrients *i.e.,* B_1- KAU package of practices (POP) recommendation (NPK @ 45:22.5:22.5 kg ha^{-1}), B_2- NPK @ 60:30:30 kg ha^{-1}, B_3- NPK @ 75:37.5:37.5 kg ha^{-1}, B_4 - Soil test based fertilizer recommendation (SBFR) @ 41:6:19 kg ha^{-1}, B_5-Control (No NPK). Full dose of phosphorus and potassium were applied as basal whereas nitrogen was applied in split doses *i.e.,* half as basal and the other half applied 30 days after sowing (DAS). Blast incidence was observed during 30 DAS and plant protection measures such as application of tebuconazole (Folicur) @ 1.5 mL/litre was done to control the blast.

Observations included growth parameters such as plant height, number of tillers hill^{-1}, number of leaves plant^{-1} and leaf area hill^{-1} taken at 25, 50, 75 DAS. Observation on dry matter production (DMP) was taken at 25, 50, 75 DAS and at harvest. Yield attributes included grain weight per panicle and per hill, number of panicles per hill, length of panicle, test weight, grain and straw yield. Nitrogen (N), phosphorus (P) and potassium (K) uptake by plants were estimated using micro kjeldahl method, vanado molybdate yellow color method and flame photometer method, respectively. Soil samples collected after harvest were analysed for organic carbon, available N, P and K using walkley - Black chromic acid wet oxidation method, alkaline potassium permanganate method, spectrophotometer method and flame photometry method, respectively. Quality parameters such as moisture, ash, crude protein and crude fat, calcium and iron content in grain were also analysed by using digital moisture meter, muffle furnace, micro kjeldahl method, soxhlet apparatus, titration method and Atomic absorption spectroscopy (AAS) method respectively.

Results and Discussion

Biometric Observations

The effect of different levels of FYM, nutrients and their interaction on growth parameters such as plant height, leaf area index, dry matter production and straw yield was statistically analysed and presented in the Table 1. Application of different nutrient levels influenced the growth parameters significantly at different stages of crop growth (25, 50 and 75 DAS). Application of NPK @ 75:37.5:37.5 kg ha^{-1} resulted in higher values of plant height (49.76, 75.60 and 96.29 cm), number of tillers hill^{-1} (2.39, 4.84 and 5.47),

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TABLE 1

Effect of different levels of FYM, nutrients and their interaction on growth parameters such as plant height, leaf area and dry matter production and straw yield

Treatments	Plant height (cm)			Leaf area index (LAI)			Dry matter production(kg ha^{-1})		Straw yield (kg ha^{-1})
	25 DAS	50 DAS	75 DAS	25 DAS	50 DAS	75 DAS	50 DAS	At harvest	
A.Levels of FYM (t ha^{-1})									
A_1 : 5	44.59	63.19 ^{b}	82.83 ^{b}	0.64	1.86 ^{b}	3.93	1755.73	6203.18	3651.77
A_2 : 10	44.13	65.58 ^{a}	86.01 ^{a}	0.66	1.91 ^{a}	3.93	1729.00	5914.44	3684.74
SEm (±)	0.574	0.43	0.65	0.007	0.005	0.009	31.95	123.13	17.62
CD (0.05)	NS	1.28	1.94	NS	0.014	NS	NS	NS	NS
B.Levels of nutrients (NPK at kg ha^{-1})									
B_1 : 45:22.5:22.5	41.75 ^{c}	58.90 ^{d}	77.08 ^{d}	0.54 ^{d}	1.86 ^{c}	3.83 ^{b}	1739.99 ^{ab}	5861.32 ^{bc}	3277.13 ^{d}
B_2 : 60:30:30	47.37 ^{ab}	69.83 ^{b}	90.54 ^{b}	0.74 ^{b}	1.94 ^{b}	3.99 ^{a}	1759.90 ^{ab}	6343.98 ^{ab}	3923.52 ^{b}
B_3 : 75:37.5:37.5	49.76 ^{a}	75.60 ^{a}	96.29 ^{a}	0.81^{a}	2.01 ^{a}	4.01 ^{a}	1878.13 ^{a}	6786.20 ^{a}	4016.44 ^{a}
B_4 : SBFR	45.44 ^{b}	63.58 ^{c}	85.29 ^{c}	0.65^{c}	1.88 ^{c}	3.98 ^{a}	1713.73 ^{b}	6423.32 ^{ab}	3823.04 ^{c}
B_5 : No NPK (control)	37.49 ^{d}	54.03 ^{e}	72.90 ^{e}	0.53^{d}	1.76 ^{d}	3.82 ^{b}	1620.08 ^{b}	5679.23 ^{c}	3303.67 ^{d}
SEm (±)	0.91	0.68	1.03	0.011	0.007	0.015	50.52	194.69	27.86
CD (0.05)	2.69	2.03	3.07	0.03	0.02	0.04	150.109	578.45	82.79
Interaction effects									
A_1B_1	43.52	59.50 ^{d}	76.70 ^{ef}	0.55 ^{e}	1.84	3.92 ^{bc}	1773.33	5964.43 ^{bc}	2962.63 ^{f}
A_1B_2	46.46	68.64 ^{b}	87.83 ^{cd}	0.71 ^{c}	1.91	3.99 ^{a}	1857.06	6005.32 ^{bc}	3883.48 ^{b}
A_1B_3	48.21	70.81 ^{b}	91.41 ^{bc}	0.78 ^{b}	1.97	4.01 ^{a}	1843.37	6596.43 ^{ab}	3993.73 ^{ab}
A_1B_4	46.81	63.83 ^{c}	85.71 ^{d}	0.67 ^{cd}	1.86	3.99 ^{a}	1763.55	6636.21 ^{ab}	3996.62 ^{ab}
A_1B_5	37.96	53.19 ^{e}	72.50 ^{f}	0.51 ^{e}	1.73	3.74 ^{d}	1541.33	6323.54 ^{abc}	3422.39 ^{d}
A_2B_1	39.99	58.30 ^{d}	77.41 ^{e}	0.53 ^{e}	1.88	3.74 ^{d}	1706.66	5758.21 ^{cd}	3591.63 ^{c}
A_2B_2	48.29	71.03 ^{b}	93.26 ^{b}	0.77 ^{b}	1.97	4.00 ^{a}	1662.75	6682.65 ^{ab}	3963.56 ^{ab}
A_2B_3	51.30	80.40 ^{a}	101.16 ^{a}	0.84 ^{a}	2.05	4.00 ^{a}	1912.88	6975.98 ^{a}	4039.16 ^{a}
A_2B_4	44.06	63.33 ^{c}	84.88 ^{d}	0.63 ^{d}	1.89	3.98 ^{ab}	1663.90	5120.43 ^{d}	3649.46 ^{c}
A_2B_5	37.03	54.87 ^{e}	73.29 ^{ef}	0.55 ^{e}	1.78	3.91 ^{c}	1698.84	5034.92 ^{d}	3184.95 ^{e}
SEm (±)	1.28	0.97	1.46	0.02	0.01	0.02	71.45	275.33	39.40
CD (0.05)	NS	2.88	4.34	0.047	NS	0.06	NS	818.05	117.08

Note: FYM applied at t ha^{-1}; Nutrients (NPK) at kg ha^{-1}; SBFR – Soil test based fertilizer recommendation

leaf area (303.81, 754.04 and 1503.56 cm^2) and leaf area index (0.81, 2.01 and 4.01) which was on par with NPK applied @ 60:30:30 kg ha^{-1} and was followed by soil test based fertilizer recommendation (SBFR) application. Whereas, the dry matter accumulation at harvest stage was higher with the application of NPK @ 75:37.5:37.5 kg ha^{-1} (6786 kg ha^{-1}) which was on par with NPK applied @ 60:30:30 kg ha^{-1} (6344 kg ha^{-1}) and SBFR (6423 kg ha^{-1}). Application of higher nutrient levels might have resulted in enhanced physiological activities leading to faster cell division, cell elongation and other metabolic processes that resulted in higher plant height (Triveni *et al*., 2020).

Plant height (at 50 and 75 DAS) and leaf area index (at 50 DAS) was significantly higher with the application of higher level of farm yard manure (FYM) @ 10 t ha^{-1} which might be attributed to the slow release of nutrients from the FYM due to slow mineralization and hence the growth parameters were significantly different at later stages of crop growth (Channabasanagowda *et al*., 2008). The interaction of FYM and nutrient levels had significant positive influence on plant height at 50 and 75 DAS. The highest plant height was recorded with the integrated application of FYM @ 10 t ha^{-1} + NPK @ 75:37.5:37.5 kg ha^{-1} (A_2B_3) followed by the application of FYM @ 10 t ha^{-1} + NPK @ 60:30:30 kg ha^{-1} (A_2B_2). The interaction effect also had significant influence on leaf area index (at 25 and 75 DAS) and dry matter production (at harvest). The values of leaf area index and dry matter production were high with the application of FYM @ 10 t ha^{-1} + NPK @ 75:37.5:37.5 kg ha^{-1} (A_2B_3) which was on par with the application of NPK @ 60:30:30 kg ha^{-1} + FYM @ 10 t ha^{-1} (A_2B_2), FYM @ 5 t ha^{-1} + SBFR (A_1B_4) and FYM @ 5 t ha^{-1} + NPK @ 75:37.5:37.5 kg ha^{-1} (A_1B_3). Similar findings were reported by Harika *et al.* (2019). Choudhary and Suri (2014) stated that integration of organic and inorganic nutrients resulted in a balanced nutrient supply which in turn increased the accumulation of photosynthates leading to higher values of growth parameters. Integrated application of FYM along with inorganic fertilizers resulted in better growth compared to the sole application of inorganic fertilizers as the efficiency of chemical fertilizers were improved in the presence of organic matter (Kumara *et al*., 2014).

Yield Attributes

The application of different nutrient levels imparted significant variation in grain weight per panicle, number of fingers per panicle and the length of panicle and were presented in Table 2. The higher number of fingers $panicle^{-1}$, grain weight $panicle^{-1}$ and panicle length was recorded with the application of NPK @ 75:37.5:37.5 kg ha^{-1} which was on par with SBFR (41:06:19 kg NPK ha^{-1}). The improvement in yield attributes by the application of high nutrient doses might be due to the addition of higher quantity of macro and micro-nutrients to the soil in the form of FYM and fertilizers thus leading to increased nutrient availability in the root zone (Vengatesan *et al*., 2021). These results are in confirmation with the findings of Poornesh *et al*. (2004).

Number of fingers per panicle varied significantly with the application of different doses of FYM. Number of fingers $hill^{-1}$ was high and low, respectively with the application of FYM @ 10 t ha^{-1} (6.74) and 5 t ha^{-1} (6.42). This could be because organic manure application provided favourable environment for microorganisms which helped in the fixation, assimilation and absorption of nutrients and thus resulting in higher yield attributes and yield as reported by Roy *et al*. (2018). There was no significant interaction effect on yield attributes.

Grain Yield

The effect of different nutrient levels application has significant influence on grain yield of finger millet and was presented in Table 2 and Fig. 1. The highest value of grain yield was recorded with the application of NPK @ 75:37.5:37.5 kg ha^{-1} (2042 kg ha^{-1}) which was on par with the application of NPK @ 60:30:30 kg ha^{-1} (2014 kg ha^{-1}) and SBFR (1957 kg ha^{-1}). The higher grain yield with higher nutrient levels could be attributed to more number of tillers, more number of fingers $panicle^{-1}$ and higher grain weight $panicle^{-1}$. An experiment conducted on precision nutrient

TABLE 2

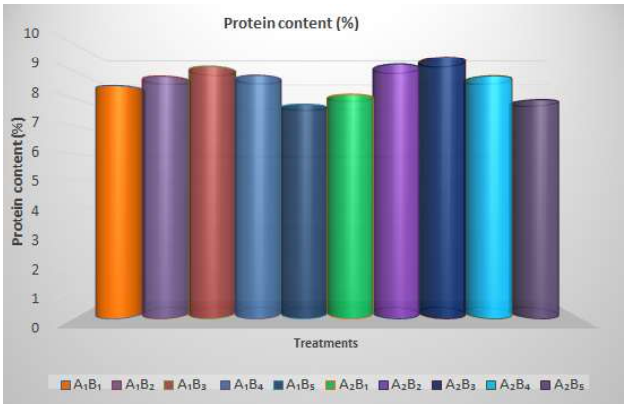
Effect of different treatments on yield attributes and yield

Treatments	Panicles hill^{-1} (No.)	Fingers panicle^{-1} (No.)	Panicle length (cm)	Grain wt. panicle^{-1} (g)	Test weight (g)	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})
A. Levels of FYM (t ha^{-1})							
A_1 : 5	4.59	6.42 ^{b}	9.77	5.40	3.22	1927.26	3651.77
A_2 : 10	4.75	6.74 ^{a}	9.74	5.51	3.21	1859.63	3685.74
SEm (±)	0.12	0.09	0.08	0.08	0.02	40.36	17.62
CD (0.05)	NS	0.27	NS	NS	NS	NS	NS
B. Levels of nutrients (NPK at kg ha^{-1})							
B_1 : 45:22.5:22.5	4.44	6.35 ^{b}	9.48 ^{bc}	5.57 ^{bc}	3.23	1842.45 ^{b}	3277.13 ^{d}
B_2 : 60:30:30	4.67	6.41 ^{b}	9.61 ^{bc}	5.76 ^{b}	3.23	2014.27 ^{ab}	3923.52 ^{b}
B_3 : 75:37.5:37.5	5.04	7.06 ^{a}	10.35 ^{a}	6.30 ^{a}	3.24	2042.17 ^{a}	4016.44 ^{a}
B_4 : SBFR	4.79	6.85 ^{a}	9.88 ^{b}	6.11 ^{ab}	3.18	1957.87 ^{ab}	3823.04 ^{c}
B_5 : No NPK	4.40	6.22 ^{b}	9.45 ^{c}	4.32 ^{c}	3.20	1621.74 ^{c}	3303.67 ^{d}
SEm (±)	0.19	0.14	0.13	0.12	0.03	65.91	27.86
CD (0.05)	NS	0.43	0.40	0.37	NS	195.82	82.79
Interaction effects							
A_1B_1	4.55	6.24	9.60	5.39	3.24	1831.66	2962.63 ^{f}
A_1B_2	4.58	6.4	9.61	5.68	3.23	2129.40	3883.48 ^{b}
A_1B_3	4.67	6.80	10.23	6.20	3.26	2013.21	3993.73 ^{ab}
A_1B_4	4.75	6.58	9.80	5.52	3.24	2049.33	3996.62 ^{ab}
A_1B_5	4.38	6.06	9.60	4.25	3.15	1644.57	3422.39 ^{d}
A_2B_1	4.33	6.47	9.36	5.76	3.21	1864.03	3591.63 ^{c}
A_2B_2	4.75	6.42	9.62	5.84	3.24	1899.15	3963.56 ^{ab}
A_2B_3	5.41	7.33	10.47	6.41	3.22	2071.13	4039.16 ^{a}
A_2B_4	4.83	7.12	9.96	5.13	3.12	1866.40	3649.46 ^{c}
A_2B_5	4.41	6.37	9.29	4.39	3.24	1598.91	3184.95 ^{e}
SEm (±)	0.27	0.20	0.19	0.18	0.04	80.72	39.40
CD (0.05)	NS	NS	NS	NS	NS	NS	117.08

management in finger millet crop stated that the higher grain yield was recorded with the application of soil test crop based recommendation (STCR) of NPK over other treatments (Saraswathi and Kumar, 2018). The results clearly establish the superior effect of soil test based fertilizer application than ad hoc recommendations. The application of different doses of FYM and the interaction effect was not significant in the case of grain yield and yield attributes.

Straw Yield

Effect of different levels of FYM, nutrients and their interaction on straw yield was presented in the Table 1. Application of higher levels of nutrients (NPK @ 75:37.5:37.5 kg ha^{-1}) resulted in higher straw yield which was followed by NPK applied @ 60:30:30 kg ha^{-1} and SBFR. The interaction effect of FYM with different nutrient levels was significant. Higher



Note :
A_1B_1 -FYM @ 5 t ha^{-1} + KAU POP (NPK @ 45:22.5:22.5 kg ha^{-1})
A_1B_2 - FYM @ 5 t ha^{-1} + NPK @ 60:30:30 kg ha^{-1}
A_1B_3 - FYM @ 5 t ha^{-1} + NPK @ 75:37.5:37.5 kg ha^{-1}
A_1B_4 - FYM @ 5 t ha^{-1} + SBFR (NPK @ 41:6:18 kg ha^{-1})
A_1B_5 - FYM @ 5 t ha^{-1}
A_2B_1 - FYM @ 10 t ha^{-1} + KAU POP (NPK @ 45:22.5:22.5 kg ha^{-1})
A_2B_2 - FYM @ 10 t ha^{-1} + NPK @ 60:30:30 kg ha^{-1}
A_2B_3 - FYM @ 10 t ha^{-1} + NPK @ 75:37.5:37.5 kg ha^{-1}
A_2B_4 - FYM @ 10 t ha^{-1} + SBFR (NPK @ 41:6:18 kg ha^{-1})
A_2B_5 - FYM @ 10 t ha^{-1}

Fig. 1. Interaction effect of different FYM and nutrient levels on grain protein content (%) of finger millet

dose of FYM along with higher nutrient levels (A_2B_3) resulted in higher value for straw yield which was on par with the application of FYM @ 5 t ha^{-1} + NPK applied @ 75:37.5:37.5 kg ha^{-1}, A_1B_4 (FYM applied @ 5 t ha^{-1} + SBFR) and A_2B_2 (FYM applied @ 10 t ha^{-1} + NPK @ 60:30:30 kg ha^{-1}). The higher dry matter production is the pre-requisite for higher straw yield. Higher straw yield was recorded with the integrated application of high dose of FYM along with high NPK levels and it may be attributed to higher nutrient availability that resulted in highest value for plant height, dry matter production and tiller production, ultimately resulting in higher straw yield. These results are in confirmation with the results of Giribabu *et al.* (2010).

Nutrient Uptake

Application of different nutrient levels resulted in significant difference in nitrogen uptake and the details are presented in Table 3. Higher nitrogen uptake was recorded with NPK applied @ 75:37.5:37.5 kg ha^{-1} (55.17 kg ha^{-1}) which was on par with the application of NPK @ 60:30:30 kg ha^{-1} (51.22 kg ha^{-1}); followed by nitrogen uptake in SBFR treatment (50.10 kg ha^{-1}). The interaction effect of FYM and nutrient levels were also significant. Highest nitrogen uptake was recorded in the treatment A_2B_3 (56.87 kg ha^{-1}) which was on par with the treatments A_1B_4 (54.03), A_2B_2 (56.21) and A_1B_3 (54.13). Lowest value of nitrogen uptake was recorded in the treatment A_2B_5 (39.11). The trend of nutrient uptake was in accordance with dry matter accumulation and high biomass production leading to high straw yield ha^{-1}. Similar findings were made by Rathore *et al*. (2006), Kalibhavi *et al*. (2003) and Prashanth *et al*. (2019).

Soil Parameters

Application of different nutrient levels resulted in significant variation between the treatments with respect to soil organic carbon (%) and available N, P and K and the details are presented in Table 3. Highest value for organic carbon was observed with NPK applied @ 75:37.5:37.5 kg ha^{-1} (0.71%) which was on par with NPK applied @ 60:30:30 kg ha^{-1} (0.67%). Varalakshmi *et al*. (2005) has reported that high organic carbon content was recorded with the application of FYM @ 7.5 t ha^{-1} + 100 per cent RDF (50:40:25 kg ha^{-1}) over the Soil Test Crop Response (STCR) approach in finger millet - groundnut cropping system.

Higher value of available nitrogen and phosphorus (266.33 and 77.61 kg ha^{-1}) was recorded with the higher dose of FYM (10 t ha^{-1}) and lower value (252.45 and 73.88 kg ha^{-1}) was recorded by the lower dose of FYM application (5 t ha^{-1}). Among the different nutrient levels, highest value of available nitrogen, phosphorus and potassium (303.06, 83.74 and 289.23 kg ha^{-1}) was recorded with NPK applied @ 75:37.5:37.5 kg ha^{-1} followed by the application of NPK applied @ 60:30:30 kg ha^{-1} (274.85, 77.74 and 273.02 kg ha^{-1}) and SBFR (255.62, 73.36 and 247.30 kg ha^{-1}).

The interaction effect of FYM and nutrient levels were also significant with respect to available nitrogen.

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TABLE 3

Effect of different treatments on soil nutrient status and nutrient uptake

Treatments	Nutrient uptake (kg ha^{-1})			Organic carbon (%)	Available nutrients (kg ha^{-1})		
	Nitrogen	Phosphorus	Potassium		Nitrogen	Phosphorus	Potassium
A. Levels of FYM (t ha^{-1})							
A_1 : 5	47.06	13.76	74.21	0.60	252.45 ^{b}	73.88 ^{b}	243.15
A_2 : 10	49.28	14.00	73.25	0.65	266.33 ^{a}	77.61 ^{a}	252.30
SEm (±)	0.88	0.81	5.43	0.016	3.35	0.84	7.54
CD (0.05)	NS	NS	NS	NS	9.95	2.50	NS
B.Levels of nutrients (NPK at kg ha^{-1})							
B_1 : 45:22.5:22.5	43.52 ^{c}	13.48	68.99	0.60 ^{b}	235.21 ^{d}	74.46 ^{bc}	224.86 ^{cd}
B_2 : 60:30:30	51.22 ^{ab}	16.02	73.46	0.67 ^{a}	274.85 ^{b}	77.74 ^{b}	273.02 ^{ab}
B_3 : 75:37.5:37.5	55.17 ^{a}	15.01	82.03	0.71 ^{a}	303.06 ^{a}	83.74 ^{a}	289.23 ^{a}
B_4: SBFR	50.10 ^{b}	10.72	72.26	0.60 ^{b}	255.62 ^{c}	73.36 ^{cd}	247.30 ^{bc}
B_5 : No NPK	40.84 ^{c}	14.18	71.91	0.55 ^{b}	228.20 ^{d}	69.44 ^{d}	204.22 ^{d}
SEm (±)	1.39	1.27	8.59	0.025	5.30	1.33	11.92
CD (0.05)	4.12	NS	NS	0.075	15.74	3.95	35.42
Interaction effects							
A_1B_1	42.90 ^{de}	13.53	66.19	0.60	229.79	73.92	225.73
A_1B_2	45.58 ^{cd}	14.16	58.18	0.64	259.44	74.82	261.50
A1B3	54.13 ^{ab}	13.04	77.38	0.67	290.85	78.62	278.45
A_1B_4	54.03 ^{ab}	12.14	80.89	0.56	258.43	73.17	251.59
A_1B_5	42.57 ^{de}	15.93	88.43	0.54	223.71	68.88	198.48
A_2B_1	44.14 ^{de}	13.44	71.80	0.60	240.63	75.00	223.99
A_2B_2	56.21 ^{a}	17.86	88.74	0.70	290.27	80.67	284.54
A_2B_3	56.87 ^{a}	16.98	86.67	0.76	315.26	88.85	300.02
A_2B_4	50.06 ^{bc}	9.3	63.63	0.62	252.82	73.55	243.01
A_2B_5	39.11 ^{e}	12.421	55.39	0.55	232.69	70.00	209.95
SEm (±)	1.96	1.80	12.15	0.036	7.49	1.88	16.862
CD (0.05)	5.83	NS	NS	NS	NS	NS	NS

High available nitrogen was recorded with the application of FYM @ 10 t ha^{-1} + NPK @ 75:37.5:37.5 kg ha^{-1} (A_2B_3) which was on par with the treatments A_2B_2 (FYM @ 10 t ha^{-1} + NPK @ 60:30:30 kg ha^{-1}) & A_1B_3 (FYM @ 5 t ha^{-1} + NPK @ 75:37.5:37.5 kg ha^{-1}). These results were similar to the findings of Nigade and More (2013), wherein the highest available N was recorded with the application of 100 per cent RDF compared to 75 per cent RDF, 50 per cent RDF and control treatment. The studies conducted by Triveni *et al*. (2018) revealed that high NPK dose (125% RDF) resulted in higher available N in soil over the lower doses (75% RDF and 100% RDF).

Quality Parameters

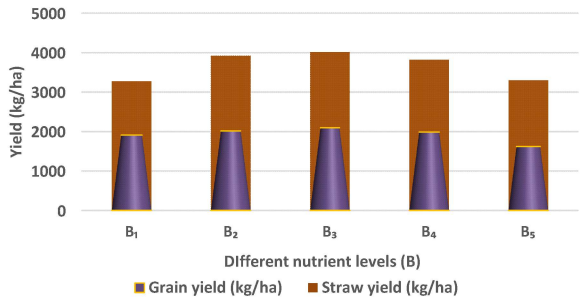
The interaction effect of FYM with nutrient levels on protein content was presented in the Fig. 2. Among

TABLE 4

Effect of different treatments on grain quality parameters

Treatments	Moisture	Ash	Protein	Fat	Calcium	Iron
			A. Levels of FYM (t ha^{-1})			
A_1 : 5	11.91	2.63	8.60	0.43	0.31	83.33
A_2 : 10	12.22	2.74	8.71	0.48	0.30	87.63
SEm (±)	0.20	0.053	0.043	0.016	0.01	3.44
CD (0.05)	NS	NS	NS	NS	NS	NS
			B. Levels of nutrients (NPK at kg ha^{-1})			
B_1 : 45:22.5:22.5	12.23	2.63 ^{bc}	8.28 ^{c}	0.40	0.30	83.17
B_2 : 60:30:30	12.48	2.57 ^{c}	9.01 ^{b}	0.47	0.31	83.75
B_3 : 75:37.5:37.5	11.82	2.83 ^{ab}	9.31 ^{a}	0.48	0.31	83.92
B_4 : SBFR	11.57	2.93 ^{a}	8.82 ^{b}	0.45	0.30	86.92
B_5 : No NPK	12.23	2.44 ^{c}	7.86 ^{d}	0.46	0.31	89.67
SEm (±)	0.31	0.084	0.07	0.026	0.02	5.43
CD (0.05)	NS	0.25	0.20	NS	NS	NS
			Interaction effects			
A_1B_1	11.90	2.67	8.44 ^{d}	0.39	0.31	82.16
A_1B_2	12.17	2.60	8.80 ^{c}	0.42	0.32	83.83
A_1B_3	11.70	2.80	9.15 ^{b}	0.46	0.32	85.33
A_1B_4	11.27	2.67	8.83 ^{c}	0.44	0.31	76.00
A_1B_5	12.53	2.40	7.78 ^{f}	0.45	0.31	89.33
A_2B_1	12.57	2.60	8.13 ^{e}	0.42	0.29	84.17
A_2B_2	12.80	2.53	9.23 ^{ab}	0.52	0.31	83.67
A_2B_3	11.93	2.87	9.48 ^{a}	0.50	0.31	82.50
A_2B_4	11.87	3.20	8.81 ^{c}	0.47	0.29	97.33
A_2B_5	11.93	2.48	7.94 ^{ef}	0.48	0.32	90.00
SEm (±)	0.44	0.12	0.10	0.037	0.02	7.68
CD (0.05)	NS	NS	0.29	NS	NS	NS

all the parameters, protein content was significantly influenced with the application of different nutrient levels and with integrated application of FYM and nutrients. The effect of different nutrient levels on protein and ash content were presented in the Table 4. Higher values of protein content in grain was recorded with the application of higher levels of nutrients (B_3) and with integrated application of high levels of FYM (10 t ha^{-1}) + NPK @ 75:37.5:37.5 kg ha^{-1} (A_2B_3). Higher nitrogen uptake with the application of higher levels of nitrogen has resulted in higher protein content in grain. Significant variation was recorded in ash content with the application of different levels of nutrient. Higher values of ash content was recorded in SFBR (2.93%) which was on par with that of NPK applied @ 75:37.5:37.5 kg ha^{-1} (2.83%). This was followed by the KAU POP treatment (2.63%). Similar trend was observed in case of dry matter accumulation.



Note :
B_1 - KAU POP recommendation (NPK @ 45:22.5:22.5 kg ha^{-1})
B_2 - NPK @ 60:30:30 kg ha^{-1}
B_3 - NPK @ 75:37.5:37.5 kg ha^{-1}
B_4 - soil test based fertilizer recommendation (NPK @ 41:6:19 kg ha^{-1})
B_5 - control plot

Fig. 2. Effect of different nutrient levels on grain and straw yield (kg ha^{-1}) of finger millet

Economic Parameters

Table 5 represents the different treatments along with their economic parameters. Higher values of gross return, net return and cost of cultivation were computed for the treatment A_2B_3 (FYM applied @ 10 t ha^{-1} + NPK applied @ 75:37.5:37.5 kg ha^{-1}) *i.e.,* Rs.99,145/-, Rs.49,342/- and Rs.49,803/- respectively. Higher doses of FYM and nutrients incurred comparatively higher cost of cultivation. However the benefit-cost ratio (BCR) was high (2.02) for A_1B_4 treatment which supplied the nutrients by FYM applied @ 5 t ha^{-1} + SBFR (NPK applied @ 41:6:19 kg ha^{-1}). This was due to the reduced cost of cultivation in this treatment as lower quantity of fertilizers were added (based on soil test) and FYM was also at lower level.

TABLE 5

Effect of different levels of FYM and nutrients on economic parameters

Treatments	Gross returns (Rs. ha^{-1})	Cost of cultivation (Rs. ha^{-1})	Net returns (Rs. ha^{-1})	Benefit-cost ratio (BCR)
A_1B_1	87091	47616	39474	1.83
A_1B_2	92073	48432	43641	1.90
A_1B_3	92542	49248	43294	1.88
A_1B_4	94065	46529	47536	2.02
A_1B_5	75917	45169	30748	1.68
A_2B_1	86510	48171	38339	1.79
A_2B_2	92780	48987	43813	1.89
A_2B_3	99145	49803	49341	1.99
A_2B_4	85688	47084	38604	1.82
A_2B_5	73524	45724	27800	1.60

The experiment revealed that even though higher grain yield was recorded with the application of higher doses of NPK (75:37.5:37.5 kg ha^{-1}), it was on par with the next higher dose (NPK @ 60:30:30 kg ha^{-1}) and the nutrient dose applied based on soil test results. Integrated application of FYM and fertilizers based on soil test results has resulted in reduced use of fertilizers by 8.88, 73.34 & 15.55 per cent (Urea, Rock phosphate, MOP respectively) over the KAU POP recommendation. Continuous sole application of chemical fertilizers even though if it is based on soil test results may result in the decrease of potential yield of finger millet and hence integrated application of organic manures along with chemical fertilizers has positive effect on finger millet on a long term basis (Swain *et al.,* 2021).

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