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Impact of watershed management practices on yield, nutrient uptake and content of finger millet crop grown in Appanahalli sub-watershed of Karnataka

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Abstract
A study was conducted to evaluate the effects of management practices on yield, nutrient uptake and concentrations of finger millet crop grown in Appanahalli sub-watershed of Gubbi taluk, Karnataka. A total of six micro watersheds under Appnahalli sub watershed with three major landforms *viz*., undulating upland or Ridge, Midland and Valley under Ragi cropping system were selected. A total of 90 plant samples were collected in a crop cutting experiment during the year 2020. Results of study indicated that Grain and straw yield of finger millet grown in Appnahalli sub-watershed varied from 15.83 to 31.12 q ha^{-1} and 19.07 to 35.61 q ha^{-1}, respectively. Higher grain and straw yield were observed in valley landform compared to midland and ridge landform. In Appanahalli sub-watershed, N, P and K concentration in finger millet grain varied from 1.11 to 1.42%, 0.10 to 0.28% and 0.33 to 1.12%, respectively, whereas, N, P, K concentration in straw varied from 0.11 to 0.88%, 0.03 to 0.19% and 0.51 to 1.48%, respectively. The uptake of N, P, K by finger millet grain and straw in Appanahalli sub-watershed ranged from 12.34 to 30.63 kg ha^{-1} and 7.39 to 20.54 kg ha^{-1}, 1.21 to 6.56 kg ha^{-1} and 1.04 to 4.99 kg ha^{-1}, and 8.63 to 31.12 kg ha^{-1} and 11.32 to 45.83 kg ha^{-1}, respectively. Significantly higher concentration of iron (79.27 and 41.16 mg kg^{-1}) followed by manganese (44.79 and 40.55 mg kg^{-1}), copper (9.91 and 9.50 mg kg^{-1}) and zinc (9.19 and 8.24 mg kg^{-1}) in grain and straw of finger millet, respectively was recorded in Appanahalli sub-watershed. An uptake of iron (187.02 and 137.02 g ha^{-1}), manganese (120.65 and 145.46 g ha^{-1}), copper (18.92 and 21.36 g ha^{-1}) and zinc (20.42 and 24.26 g ha^{-1}) by grain and straw of finger millet were recorded, respectively. A comparatively higher uptake of all the micro-nutrients were found in valley landform than midland and ridge landform due to higher organic matter and nutrient accumulation. Hence, proper and adequate management practices need to be adopted for bringing the soils to favourable soil reactions to a better fertility and productivity conditions.

Keywords: Watershed, fertility, yield, nutrient uptake, nutrient content

1. Introduction
Finger millet (*Eleusine coracana* (L.) Gaertn) is the most important small millet in the tropics (12% of global millet area), and is cultivated in more than 25 countries in Africa and Asia, predominantly as a staple food grain. Finger millet has high yield potential (>10 Mg ha^{-1} under optimum irrigated conditions). In India, it is cultivated on 1.8 M ha, with average yields of 1.3 Mg ha^{-1} (FAO, 2007) [2]. Major finger millet growing area is confined to the southern parts of India. Positive trend of yield is observed with the application of organics along with mineral fertilizers. Soil resources inventory requires a good understanding of the properties and process of different soils in a given area so that their mapping becomes easy. As we have to meet the challenges of this country, new understandings and new technologies will be needed to protect the environment and at the same time produce food and biomass to support society. Systematic study of morphology and taxonomy of soils provides information on nature and type of soils, their constraints, potentials, capabilities and their suitability for different uses. Watershed management practices change the land use, vegetative cover and other non-structural and structural actions that are taken to achieve the management objectives.
Therefore, a study of the soils of the watershed is important to contribute to an increase in agricultural productivity. Integrated watershed management is a holistic approach which aims at optimizing the use of land, water and vegetation in an area to alleviate drought, moderate floods, prevent soil erosion, improve water availability and increase fuel wood, fodder and agricultural production on a sustained basis (Mekonnen *et al.*, 2014) [8] and to restore the natural resource base in a manner that contributes to climate change adaptation and mitigation.

2. Material and Methods

2.1 Study area

Appanahalli sub-watershed is located in central Karnataka plateau with hot, moist, semi-arid eco sub region, Southern plateau and hill region which belongs to the sub region 8.2 of Karnataka. The sub-watershed (Gubbi taluk, Tumkuru district) is located in between 130 29' 36.94" and 130 25'48.015" North latitude and 760 43'27.767" and 760 48'58.762" East longitudes covering an area of 3484 ha, consists of 6 micro watersheds- a) Singadahalli, b) Galigerkere-1, c) Galigerkere-2, d) Galigerkere-3, e) Haradagere-2 and f) Appanahalli-1. The area receives an average annual rainfall of 679.1-888.9 mm, 50% of which is received mainly during kharif season. The elevation of the sub-watershed is 800-900 m above mean sea level. The relief of the study area is very gently sloping to gently sloping, where very gently sloping land covers an area of 1956 ha (56.2%) and gently sloping land occupy 820 ha (23.5%) area. The major crop cultivated in the watershed is Ragi. On the basis of a soil survey and fertility analysis (2017), soil physico-chemical properties and Several management practices that have been implemented in the sub-watershed are shown in Table 1 and 2, respectively.

2.2 Collection of plant samples

Plant samples were collected at the time of harvesting. A total of 5 farmers were approached for the collection of plant samples from all 3 land forms (Ridge, midland and valley) having ragi crop. Ragi straw was dried under the sun for about one week and weighed in each plot and their yield was expressed as kg ha^{-1}. Grains were separated from the fingers by beating manually with sticks after drying in threshing yard. Clean seeds were weighed and expressed as kg ha^{-1}.

Table 1: Soil physico-chemical properties of Appanahalli sub-watershed

Soil Parameter	Values
pH	6.50
Electrical conductivity	0.16 dSm^{-1}
Bulk density	1.43 Mg m^{-3}
Organic carbon	0.50%
Available nitrogen	228.00 kg ha^{-1}
Available phosphorus	33.81 kg ha^{-1}
Available potassium	211.39 kg ha^{-1}
DTPA-extractable Fe	8.98 mg kg^{-1}
DTPA-extractable Mn	8.83 mg kg^{-1}
DTPA-extractable Zn	0.76 mg kg^{-1}
DTPA-extractable Cu	1.10 mg kg^{-1}

Table 2: Watershed interventions adapted in Appanahalli sub-watershed (2017)

Watershed	Interventions
Appanahalli-1	1. Summer ploughing 2. Sowing across the slope
Galigerekere-1	1. Graded bund 2. Vegetative barrier 3. Addition of FYM 4. Levelling of land 5. Sowing across slope and split application of nitrogen fertilizer
Galigerkere-2	1. Formation of ridges 2. Trench cum bund 3. Dead furrow 4. Crescent bund for horticulture crop
Galigerkere-3	1. Addition of organic manure 2. Dead furrows between crops 3. Formation of ridge and furrow 4. Split application of nitrogen fertilizer
Haradagere	1. Use of green manure crops in plantation. 2. Use of slow releasing fertilizer
Singadahalli	1. Summer ploughing and sowing across slope. 2. Levelling and vegetative bunding to reduce soil loss due to erosion. 3. Intercropping instead of sole cropping.

2.3 Plant analysis

Straw and grain samples of finger millet from randomly selected plants in each plot were collected, dried and powdered. For nitrogen, 0.5 grams of grain and straw samples were digested with concentrated sulphuric acid (H2SO4) and digestion mixture having composition of (K2SO4: CuSO4.5H2O: Selenium in 100: 20: 1 proportion) till a bluish-green residue was leftover and cooled after taking out. The extract used for estimation of P, K, Ca, Mg and micronutrients *viz.*, Fe, Cu, Mn, Zn and B were prepared by using one gram of the dried and powdered plant samples of grain and straw digested with10 ml diacid mixture consisting of (HNO3 + HClO4) in 10:4 ratio. After digestion of plant samples, nutrient content and uptake of finger millet crop was estimated using standard procedures.

3. Results and discussion

In the given study, the effect of different management practices on yield, nutrient content and uptake of finger millet crop grown on Appanahalli sub-watershed was observed. The results are discussed below.

3.1 Effect of watershed based management practices on grain and straw yield of Ragi crop

Grain and straw yield of finger millet grown in Appnahalli sub-watershed varied from 15.83 to 31.12 q ha^{-1} (23.28 q ha^{-1}) and 19.07 to 35.61 q ha^{-1} (27.12 q ha^{-1}), respectively (Table 3). Higher grain and straw yield were observed in valley landform compared to midland and ridge landform because of surface accumulation of nutrients and organic matter in valley landform. Comparing with the earlier study of 2017, there is little increase in yield of finger millet crop in 2020, because of adoption of better nutrient management practices (Fig 1).

Integrated application of organic and inorganic sources showed beneficial effect on physiological process of plant

metabolism and growth, thereby resulting in higher grain and straw yield. Mineralization of organic manures enhanced nitrogen which not only influenced the shoot and root growth but also favored absorption of other nutrients. Similar results were obtained by Basavaraju and Purushotham (2009) [3] and Yakadri and Reddy (2009) [1].

Higher yield due to inorganic fertilizers in combination with FYM was not only due to sustained nutrient supply but also due to better utilization of applied nutrients through improved microbial activity that involved nutrient transformation and fixation due to organic manuring (Arbad and Ismail, 2002) [7]. Manna *et al.* (2005) [7] reported a similar positive yield trend in the NPK and NPK + FYM treatments in a soybean– wheat system on *Alfisols* at Ranchi.

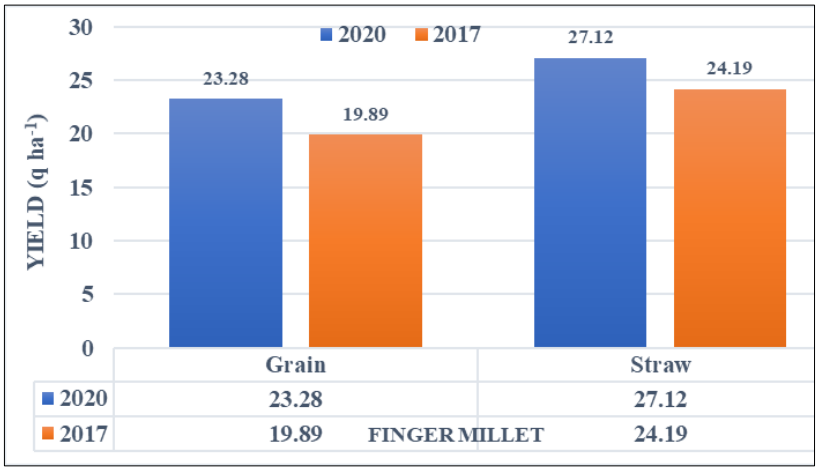

Fig 1: Effect of watershed based interventions on yield of finger millet from 2017 to 2020 in Appanahalli sub-watershed, Karnataka

Table 3: Grain and straw yield of Finger millet grain and straw grown in different landforms of Appanahalli sub-watershed, Karnataka

Watershed	Land form	Grain yield (q/ha)	Straw yield (q/ha)
Appanahalli-1	Valley	15.86-29.81	19.23-32.17
	Midland	18.92-27.32	22.41-31.24
	Ridge	17.96-28.19	21.18-30.02
	Mean	22.54	26.51
Galigerkere-1	Valley	22.67-28.12	26.18-30.19
	Midland	22.18-31.12	24.23-34.12
	Ridge	15.83-22.78	19.07-25.17
	Mean	23.86	27.06
Galigerkere-2	Valley	20.02-26.17	24.15-30.42
	Midland	21.09-28.43	25.96-32.45
	Ridge	18.51-22.31	22.43-26.19
	Mean	22.65	26.91
Galigerkere-3	Valley	21.34-29.56	24.81-35.61
	Midland	20.05-27.12	24.17-30.12
	Ridge	17.61-21.12	21.12-28.19
	Mean	23.48	27.84
Haradagere	Valley	22.41-29.31	25.61-32.41
	Midland	20.09-27.71	25.61-31.13
	Ridge	17.23-21.13	20.01-26.76
	Mean	22.96	26.79
Singadahalli	Valley	24.65-30.02	21.19-34.87
	Midland	21.09-28.91	24.51-33.42
	Ridge	18.87-22.32	22.14-26.71
	Mean	24.20	27.61
Appanahalli	Range	15.83-31.12	19.07-35.61
	Grand Mean	23.28	27.12

3.2 Macro Nutrient concentration and uptake in Finger millet

The concentration of nitrogen, phosphorus and potassium in finger millet grain and straw differed among different landforms of watershed. In Appanahalli sub-watershed, N, P and K concentration in finger millet grain varied from 1.11 to 1.42% (1.23%), 0.10 to 0.28% (0.18%) and 0.33 to 1.12% (0.67%), respectively, whereas, N, P, K concentration in straw varied from 0.11 to 0.88% (0.55%), 0.03 to 0.19% (0.10%) and 0.51 to 1.48% (0.97%), respectively (Table 4). Among all the major landforms studied, major nutrient (N, P, K) concentration in both grain and straw were higher in Valley landform compared to midland and ridge landform.

The uptake of N, P, K by finger millet grain and straw in Appanahalli sub-watershed ranged from 12.34 to 30.63 kg ha^{-1} (19.63 kg ha^{-1}) and 7.39 to 20.54 kg ha^{-1} (14.11 kg ha^{-1}), respectively, 1.21 to 6.56 kg ha^{-1} (4.19 kg ha^{-1}) and 1.04 to 4.99 kg ha^{-1} (3.00 kg ha^{-1}), respectively, and 8.63 to 31.12 kg ha^{-1} (17.99 kg ha^{-1}) and 11.32 to 45.83 kg ha^{-1} (30.71 kg ha^{-1}), respectively (Table 5).

Table 4: Macro-nutrient (N, P, K) concentration in grain and straw of Finger millet

Watershed	Landform	N (%)		P (%)		K (%)	
		GRAIN	STRAW	GRAIN	STRAW	GRAIN	STRAW
Appanahalli-1	Valley	1.22-1.31	0.59-0.81	0.16-0.22	0.06-0.13	0.59-0.89	1.01-1.27
	Midland	1.24-1.30	0.63-0.79	0.17-0.24	0.08-0.17	0.51-0.62	0.93-1.05
	Ridge	1.19-1.30	0.60-0.79	0.15-0-.22	0.06-0.17	0.36-0.50	0.54-0.81
	Mean	1.26	0.70	0.19	0.11	0.56	0.91
Galigerkere-1	Valley	1.21-1.29	0.58-0.78	0.14-0.20	0.05-0.10	0.77-1.07	1.13-1.48
	Midland	1.25-1.42	0.65-0.88	0.15-0.26	0.07-0.18	0.54-0.72	0.91-1.17
	Ridge	1.11-1.22	0.54-0.61	0.10-0.15	0.03-0.06	0.33-0.51	0.53-0.83
	Mean	1.24	0.67	0.17	0.08	0.65	0.99
Galigerkere-2	Valley	1.18-1.28	0.55-0.78	0.15-0.21	0.07-0.18	0.58-0.89	1.01-1.23
	Midland	1.19-1.33	0.57-0.82	0.15-0.23	0.06-0.19	0.51-0.68	0.92-1.09
	Ridge	1.14-1.23	0.45-0.63	0.11-0.20	0.05-0.15	0.33-0.62	0.51-0.79
	Mean	1.22	0.61	0.16	0.12	0.61	0.97
Galigerkere-3	Valley	1.19-1.36	0.54-0.84	0.12-0.23	0.05-0.14	0.62-1.03	1.03-1.41
	Midland	1.17-1.26	0.44-0.57	0.13-0.25	0.06-0.13	0.57-0.84	0.88-1.14
	Ridge	1.13-1.21	0.31-0.57	0.11-0.19	0.03-0.09	0.41-0.79	0.55-0.87
	Mean	1.23	0.55	0.15	0.08	0.59	0.88
Haradagere	Valley	1.18-1.36	0.32-0.83	0.13-0.21	0.09-0.16	0.71-1.08	1.09-1.34
	Midland	1.16-1.32	0.32-0.77	0.14-0.19	0.07-0.11	0.65-0.89	0.93-1.16
	Ridge	1.12-1.18	0.11-0.21	0.12-0.17	0.03-0.09	0.33-0.67	0.51-0.78
	Mean	1.21	0.44	0.16	0.11	0.61	0.83
Singadahalli	Valley	1.21-1.38	0.52-0.86	0.16-0.28	0.09-0.15	0.81-1.12	1.15-1.46
	Midland	1.18-1.32	0.46-0.81	0.14-0.21	0.08-0.11	0.59-0.77	0.81-1.06
	Ridge	1.12-1.17	0.29-0.44	0.11-0.20	0.04-0.09	0.41-0.73	0.57-0.81
	Mean	1.23	0.56	0.18	0.12	0.63	0.80
Appanahalli	Range	1.11-1.42	0.11-0.88	0.10-0.28	0.03-0.19	0.33-1.12	0.51-1.48
	Mean	1.23	0.55	0.17	0.10	0.61	0.89

Nutrient concentration and nutrient uptake by finger millet grain and straw, both were higher in valley landform in comparison with ridge and midland landform in Appanahalli sub-watershed. This is in correlation with higher soil available major nutrient concentration in valley landform which lead to higher uptake and concentration of N, P and K in finger millet grain and straw. Adoption of nutrient management practices by farmers also led to higher uptake of nitrogen, phosphorus and potassium. This might be attributed to the higher dry matter production and also higher nutrient concentration with combined use of organic and inorganic fertilizers and inclusion of legume in rotation. In addition, integrated nutrient management provided favourable soil environment encouraging better root proliferation, which explored larger volume of soil for nutrient absorption and ensured higher nutrient uptake. These results are in close proximity to observations recorded by Ahmed *et al*. (2014) [1] under INM in Inceptisols. The synergistic effect of addition of FYM to soil for higher NPK uptake by rice was also reported by Sharma and Bali (2001) [9].

Table 5: Macro-nutrient (N, P, K) uptake by grain and straw of Finger millet

Watershed	Landform	N (kg ha-1)		P (kg ha-1)		K (kg ha-1)	
		GRAIN	STRAW	GRAIN	STRAW	GRAIN	STRAW
Appanahalli-1	Valley	16.61-21.32	12.24-14.23	4.20-5.52	2.98-4.09	13.45-27.64	25.73-45.66
	Midland	15.83-20.09	12.45-16.19	4.16-5.12	3.07-3.98	14.23-26.10	26.99-44.23
	Ridge	12.34-15.61	8.97-10.23	1.82-3.49	1.47-2.77	8.63-14.76	16.12-24.31
	Mean	17.25	8.97	4.15	3.10	18.23	31.72
Galigerekere-1	Valley	15.87-22.83	11.32-13.21	4.23-5.71	2.91-4.06	13.61-26.82	26.78-44.29
	Midland	15.45-20.12	12.34-16.09	4.17-5.09	3.02-4.12	13.23-25.81	25.83-43.21
	Ridge	13.42-15.13	7.39-10.19	2.12-4.12	1.87-3.09	10.12-12.39	15.91-23.98
	Mean	17.82	8.65	4.21	3.41	18.67	32.02
Galigrkere-2	Valley	16.12-23.41	12.31-15.66	4.87-6.18	3.01-4.16	14.29-27.12	26.51-43.23
	Midland	16.04-20.19	15.83-21.54	4.23-5.99	3.09-4.54	13.19-24.32	25.79-40.12
	Ridge	13.21-15.98	12.43-14.19	1.89-3.77	1.78-2.98	9.83-13.45	13.12-23.67
	Mean	16.98	8.99	4.04	3.25	18.04	31.19
Galigerkere-3	Valley	18.12-27.82	14.07-17.23	3.87-5.12	2.99-3.51	15.29-28.12	27.21-44.73
	Midland	17.12-23.49	16.12-18.78	3.44-4.97	2.01-4.99	11.49-22.62	23.49-38.22
	Ridge	14.43-18.91	11.39-15.41	1.75-2.19	1.65-1.98	10.63-15.25	14.52-24.87
	Mean	18.12	9.02	3.76	2.65	19.23	33.41
Haradagere	Valley	24.51-30.63	16.71-20.54	4.98-6.12	3.12-3.98	12.29-24.82	25.52-40.23
	Midland	22.19-28.71	14.29-16.81	4.21-6.19	2.99-3.43	14.89-25.12	27.19-45.62
	Ridge	16.17-19.23	11.32-15.77	1.21-2.97	1.04-2.15	9.77-13.39	11.32-21.47
	Mean	22.19	11.03	4.12	2.71	17.99	32.76
Singadahalli	Valley	22.31-29.07	14.23-17.87	4.19-5.87	2.99-3.67	16.40-31.12	28.10-45.83
	Midland	20.12-27.63	11.32-15.43	4.08-5.99	2.76-3.45	15.73-25.91	26.79-43.42
	Ridge	15.16-17.65	10.29-12.19	2.12-3.83	1.23-2.81	11.83-16.12	14.92-25.19

	Mean	20.18	10.87	4.05	2.41	21.80	34.56
Appanahalli	Range	12.34-30.63	7.39-21.54	1.21-6.19	1.04-4.99	8.63-31.12	11.32-45.83
	Mean	18.76	9.59	4.06	2.92	18.99	32.61

3.3 Micro Nutrient concentration and uptake in Finger millet

The concentration of iron, manganese, copper and zinc in finger millet grain and straw differed among landforms of Appanahalli sub-watershed. Significantly higher concentration of iron (79.27 and 41.16 mg kg^{-1}) followed by manganese (44.79 and 40.55 mg kg^{-1}), zinc (9.19 and 8.24 mg kg^{-1}) and copper (9.91 and 9.50 mg kg^{-1}) in grain and straw of finger millet, respectively was recorded in Appanahalli sub-watershed due to adoption of better nutrient management practices *viz*., application of FYM, crop rotation etc (Table 6 and 7).

In Appanahalli sub-watershed grain and straw uptake of iron (187.02 and 137.02 g ha^{-1}), manganese (120.65 and 145.46 g ha^{-1}), zinc (18.92 and 21.36 g ha^{-1}) and copper (20.42 and 24.26 g ha^{-1}) by finger millet were recorded, respectively (Table 8 and 9). A comparatively higher uptake of all the micro-nutrients were found in valley landform than midland and ridge landform due to higher organic matter and nutrient accumulation.

Table 6: Micro-nutrient (Fe and Mn) concentration in grain and straw of Finger millet

Watershed	Landform	Fe (mg/kg)		Mn (mg/kg)	
		GRAIN	STRAW	GRAIN	STRAW
Appanahalli-1	Valley	80.21-83.27	44.36-51.55	43.35-53.16	35.88-48.55
	Midland	77.67-82.13	37.73-49.09	40.09-44.21	36.12-41.12
	Ridge	70.21-79.32	30.19-40.12	32.31-40.02	30.12-35.51
	MEAN	78.26	41.48	42.61	38.88
Galigerkere-1	Valley	80.98-84.32	41.08-46.61	44.12-52.09	40.08-47.19
	Midland	78.81-81.18	41.13-43.98	42.38-50.03	36.64-47.18
	Ridge	70.19-79.98	30.21-38.87	33.41-40.12	30.91-37.12
	MEAN	79.51	40.34	43.48	39.63
Galigerkere-2	Valley	81.76-84.42	41.58-45.61	51.18-56.89	44.72-53.42
	Midland	79.81-81.28	40.13-43.43	44.51-52.32	40.09-48.12
	Ridge	69.19-79.98	31.21-37.91	33.99-40.12	26.54-35.78
	MEAN	79.71	40.23	46.91	42.28
Galigerkere-3	Valley	80.88-83.57	44.36-51.55	51.68-56.92	47.66-53.46
	Midland	78.67-80.61	37.73-49.29	42.51-51.32	37.18-45.64
	Ridge	70.11-79.32	30.79-40.12	34.01-41.12	29.08-37.81
	MEAN	79.05	41.60	46.69	42.25
Haradagere	Valley	81.88-84.32	45.36-52.55	44.92-53.09	40.21-50.09
	Midland	78.21-81.13	37.73-49.89	42.38-50.93	38.76-45.66
	Ridge	71.11-79.82	30.91-40.12	32.41-40.12	27.91-35.61
	MEAN	79.50	41.76	43.99	39.75
Singadahalli	Valley	80.88-87.32	44.19-51.59	45.72-55.76	41.21-50.78
	Midland	78.62-80.71	37.23-49.79	40.19-50.93	36.65-45.61
	Ridge	70.21-79.42	30.59-41.12	32.41-49.87	29.67-44.51
	Mean	79.06	41.54	45.05	40.57
Appanahalli	Range	69.19-87.32	30.19-52.55	32.31-56.92	26.54-53.46
	Mean	79.27	41.16	44.79	40.55

Table 7: Macro-nutrient (Cu and Zn) concentration in grain and straw of Finger millet

Watershed	Landform	Cu (mg/kg)		Zn (mg/kg)	
		GRAIN	STRAW	GRAIN	STRAW
Appanahalli-1	Valley	10.13-10.83	9.05-10.60	9.01-9.46	8.04-9.00
	Midland	9.32-10.11	8.89-9.82	8.69-9.00	7.54-8.12
	Ridge	8.82-9.30	8.11-9.01	8.42-8.71	7.12-7.88
	MEAN	9.78	9.28	8.87	7.95
Galigerkere-1	Valley	10.45-11.46	10.03-11.14	9.25-10.41	8.15-9.32
	Midland	9.21-10.23	8.87-9.89	8.89-9.33	7.79-8.43
	Ridge	8.19-9.05	7.78-8.69	8.54-8.87	7.65-7.98
	MEAN	9.72	9.30	9.15	8.22
Galigerkere-2	Valley	10.46-11.51	10.14-11.19	9.33-10.41	8.32-9.54
	Midland	9.16-10.33	8.87-10.04	8.56-9.22	7.66-8.23
	Ridge	8.19-9.15	7.76-8.87	8.12-8.49	7.32-7.51
	MEAN	9.77	9.48	9.01	8.10
Galigerkere-3	Valley	10.13-11.46	9.71-11.16	9.38-10.33	8.45-9.35
	Midland	9.78-10.11	9.18-9.96	8.78-9.31	7.91-8.25
	Ridge	9.14-9.81	8.87-9.76	8.29-8.71	7.41-7.72
	MEAN	10.04	9.67	9.18	8.20
Haradagere	Valley	10.13-11.83	9.84-11.21	9.56-10.55	8.61-9.45
	Midland	9.78-10.51	9.31-10.12	9.29-9.45	8.21-8.78

	Ridge	9.29-9.81	8.67-9.21	8.59-9.12	7.65-8.23
	MEAN	10.23	9.78	9.44	8.51
Singadahalli	Valley	10.33-11.83	9.98-11.32	9.61-10.34	8.56-9.41
	Midland	9.52-10.21	9.32-9.99	9.32-9.60	8.12-8.65
	Ridge	8.89-9.41	8.21-8.95	8.67-9.20	7.59-8.23
	MEAN	9.96	9.56	9.48	8.42
Appanahalli	Range	8.19-11.83	7.76-11.32	8.12-10.55	7.12-9.67
	Mean	9.91	9.50	9.19	8.24

Enhanced uptake of zinc, copper, manganese and iron by soybean was reported by Dadhich and Somani (2007) [4] with increasing level of organic manure application. This could be attributed to the positive effect on root growth, higher CEC of the soil and chelation effect after organic manure application. Higher root proliferation was accompanied by higher absorption of micronutrients with limited diffusion in the soil. Similar findings were reported by El- Fayoumi and Ramadan (2002) [5].

Table 8: Micro-nutrient (Fe and Mn) uptake by grain and straw of Finger millet

Watershed	Landform	Fe (g/ha)		Mn (g/ha)	
		GRAIN	STRAW	GRAIN	STRAW
Appanahalli-1	Valley	172.12-221.41	122.13-171.41	105.80-160.79	122.77-175.18
	Midland	159.81-181.77	109.81-131.77	90.12-100.21	119.12-129.21
	Ridge	149.81-164.23	99.81-114.23	80.21-88.76	109.21-117.76
	Mean	172.64	122.64	104.29	127.68
Galigerkere-1	Valley	180.43-254.60	130.43-204.60	110.91-143.21	138.91-171.21
	Midland	167.18-180.01	117.18-130.01	97.87-109.81	120.37-132.31
	Ridge	150.09-167.18	100.09-117.181	87.66-95.61	110.51-118.46
	Mean	180.30	129.74	108.35	132.80
Galigerkere-2	Valley	197.65-231.43	147.65-181.43	132.98-159.81	160.10-186.93
	Midland	175.64-192.34	125.64-140.16	125.66-131.23	152.78-158.35
	Ridge	156.99-167.81	106.99-117.81	116.57-126.78	143.69-153.90
	Mean	188.23	136.67	130.83	157.95
Galigerkere-3	Valley	195.65-241.23	145.65-191.23	133.45-157.81	161.43-185.79
	Midland	172.64-192.34	122.64-140.60	126.59-134.65	150.02-158.08
	Ridge	155.99-169.32	105.99-119.32	119.81-125.76	143.24-149.19
	Mean	188.80	137.58	132.77	157.72
Haradagere	Valley	199.81-245.61	149.81-195.61	115.91-144.27	139.89-168.25
	Midland	180.12-200.18	137.67-150.18	96.87-110.61	120.85-134.59
	Ridge	159.81-179.76	117.54-129.76	85.66-96.61	109.64-120.59
	Mean	194.31	147.70	108.71	132.69
Singadahalli	Valley	213.45-250.61	163.45-200.61	145.76-156.61	173.76-184.61
	Midland	188.78-209.89	138.78-159.89	136.61-143.32	160.02-166.73
	Ridge	156.71-170.12	106.71-120.12	112.31-135.98	135.72-159.39
	Mean	197.85	146.79	138.95	163.89
Appanahalli	Range	149.81-254.60	99.81-204.60	80.21-160.79	109.21-186.93
	Mean	187.02	137.02	120.65	145.46

Table 9: Micro-nutrient (Cu and Zn) uptake by grain and straw of Finger millet

Watershed	Landform	Cu (g/ha)		Zn (g/ha)	
		GRAIN	STRAW	GRAIN	STRAW
Appanahalli-1	Valley	16.43-28.61	20.89-33.50	14.47-24.99	16.97-28.45
	Midland	15.66-16.12	18.91-20.23	11.29-14.14	13.23-15.61
	Ridge	14.00-15.21	18.17-20.09	10.45-12.08	12.87-14.12
	Mean	18.04	21.96	14.95	17.07
Galigerkere-1	Valley	20.33-27.81	24.19-31.12	20.32-23.42	23.43-27.81
	Midland	18.85-20.31	21.32-24.54	17.32-20.12	20.09-23.41
	Ridge	17.86-18.67	20.97-21.87	11.25-18.21	15.43-20.02
	Mean	20.46	24.08	18.76	21.59
Galigerkere-2	Valley	22.32-27.98	25.65-31.41	21.13-25.61	23.41-29.81
	Midland	20.76-22.19	24.31-26.71	17.67-20.44	20.19-23.46
	Ridge	17.66-19.91	21.76-23.19	14.32-18.19	17.66-21.13
	Mean	21.69	25.57	19.75	22.62
Galigerkere-3	Valley	20.99-27.81	24.19-31.42	20.98-23.43	22.91-26.51
	Midland	18.98-20.76	21.99-24.97	18.82-22.12	20.98-24.43
	Ridge	15.88-18.85	18.78-22.31	14.83-20.09	16.51-23.41
	Mean	20.47	24.21	19.76	22.23
Haradagere	Valley	21.98-27.45	24.51-30.24	20.19-25.87	23.43-27.86
	Midland	19.78-21.83	23.41-25.61	17.91-20.11	19.18-23.11

	Ridge	18.32-19.45	21.33-24.65	14.32-17.65	16.88-20.05
	Mean	21.29	24.96	19.61	21.95
Singadahalli	Valley	20.78-25.16	24.55-29.01	22.61-28.97	24.51-30.12
	Midland	19.87-20.55	23.12-25.65	18.83-21.13	20.12-23.43
	Ridge	17.98-19.31	21.78-25.01	14.96-18.31	17.19-20.12
	Mean	20.54	24.75	20.67	22.64
Appanahalli	Range	14.00-28.61	18.17-33.50	10.45-28.97	12.87-30.12
	Mean	20.42	24.26	18.92	21.36

Application of FYM increased micronutrient uptake due to higher organic matter which is a potential source of micronutrients and improved physico-chemical properties of soil. On mineralization of FYM micronutrients are brought into soluble and available form, which might ultimately improve the nutrient status of the plants. These results are in close association with findings of Tarafdar and Rao (2001) [10].

References

1. Ahmed S, Basumatary A, Das KN, Medhi BK, Srivastava AK. Effect of integrated nutrient management on yield, nutrient uptake and soil fertility in autumn rice in an *Inceptisol* of Assam. Ann. Plant Soil Res. 2014;16(3):192-197.
2. Arbad BK, Ismail S. Effect of integrated nutrient management on soybean (Glycine max)-safflower (*Carthamus tinctorius*) cropping system. Indian J Agron. 2002;56(4):340-345.
3. Basavaraju TB, Purushotham S. Integrated nutrient management in rainfed ragi [*Eleusine coracana* (L.) Gaertn.]. Mysore J Agric. Sci. 2009;43(2):366-368.
4. Dadhich S, Somani L. Effect of integrated nutrient management in a soybean-wheat crop sequence on the yield, micronutrient uptake and post-harvest availability of micronutrients on *Typic Ustochrepts* soil. Acta Agronomica Hungarica. 2007;55(2):205-216.
5. El-Fayoumy ME Ramadan HM. Effect of bio-organic manures on sandy soils amelioration and peanut productivity under sprinkler irrigation system. Egypt. J Soil Sci. 2002;42:383-415.
6. FAO. Land evaluation, towards a revised framework. Land and Water Discussion Paper 6. Rome, Italy; c2007.
7. Manna MC, Swarup A, Wanjari RH, Ravankar HN, Mishra B, Saha MN, *et al*. Long-term effect of fertilizer and manure application on soil organic carbon storage, soil quality and yield sustainability under sub-humid and semi-arid tropical India. Field Crops Res. 2005;93(2-3):264-280.
8. Mekonnen M, Keesstra SD, Stroosnijder L, Baartman JEM, Maroulis J. Soil conservation through sediment trapping: a review. Land Degrad. Dev. 2014;26:544-556.
9. Sharma MP, Bali SV. Long term effect of different cropping systems on physico chemical properties and soil fertility. J Indian Soc. Soil Sci. 2001;48(1):181-183.
10. Tarafdar JC, Rao AV. Response of cluster bean to *Glomus mosseae* and rhizobium in an arid soil fertilized with nitrogen, phosphorus and farmyard manure. J Indian Soc. Soil Sci. 2001;49(4):751-755.
11. Yakadri M, Reddy APK. Productivity of pearl millet (*Pennisetum glaucum* L.) as influenced by planting pattern and nitrogen levels during summer. J Res. ANGRAU. 2009;37(1 & 2):34-37.